Urban Best Management Practice Manual

Conservation Practices to Protect Surface and Ground Water

Wyoming Department of Environmental Quality
Water Quality Division
Nonpoint Source Program

2013 Update
Document #13-0037

The purpose of this document is to provide information about best management practices that the Wyoming Nonpoint Source Program supports as eligible for Clean Water Act Section 319 funding. This document is prepared as part of the Wyoming Nonpoint Source Management Plan as required by Section 319(b) of the Clean Water Act.

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Section 1: Introduction

1.1 Purpose of this Document

The purpose of this document is to provide information about urban best management practices (BMPs) that can be voluntarily implemented to prevent, reduce, or eliminate nonpoint source pollution to Wyoming's water resources. This document focuses on those BMPs that the Wyoming Department of Environmental Quality (WDEQ), Nonpoint Source Program has determined to be eligible for Clean Water Act (CWA) Section 319 funding. This document is prepared as part of the Wyoming Nonpoint Source Management Plan as required by Section 319(b) of the CWA, which states that management programs and BMPs must be developed by each state to reduce identified causes of nonpoint source pollution.

The Wyoming Nonpoint Source Program works through voluntary and incentive methods to reduce nonpoint source pollution and will work with agencies, individual producers, and other stakeholders to promote the implementation of BMPs on a voluntary basis with financial assistance from Section 319 grants. More information about Section 319 grants and how to apply for grant funding can be found on the Nonpoint Source Program website. Please note that Section 319 funds are not eligible for activities that are required as part of a permitting or regulatory action.

Inclusion of a BMP in this manual does not guarantee Section 319 funding for that BMP. The Wyoming Nonpoint Source Program will recommend funding for BMP implementation projects on a project-by-project basis, and will take into consideration the advantages and limitations of proposed BMPs to evaluate the most efficient and cost-effective solutions possible.

1.2 How to Use this Document

The Wyoming Nonpoint Source Program recognizes that there is already a considerable amount of information available to the public about urban BMPs. Thus, this document, rather than providing an exhaustive compilation or description of those BMPs, instead provides a summary of selected BMPs and references to detailed information about those BMPs. This document should be used as follows:

- As documentation of which urban BMPs the Wyoming Nonpoint Source Program and Nonpoint Source Task Force will consider for Section 319 funding,
- As a tool to direct users to detailed information about selected BMPs, and
- As an educational tool about urban BMPs and nonpoint source pollution from urban areas.

The technology of urban BMPs has rapidly advanced in recent years as management agencies and local groups seek new and innovative ways to effectively deal with pollution from urban runoff. New types of BMPs are being developed and old BMPs may be upgraded to increase their efficiency. To the maximum extent possible, the Wyoming Nonpoint Source Program has sought to make this manual a flexible, living document to accommodate new urban BMP technologies as they are developed. This document groups BMPs according to general categories and provides a description of each category. In addition, this document provides a basic description of each BMP, a brief summary of their feasibility and maintenance needs, a list of their advantages and disadvantages, and links to reference documents where more detailed information can be found on that BMP. Thus, as stated previously, this document is not an exhaustive resource on BMP design and implementation, but rather, should be used as an educational tool and as a directory of where to find detailed information about selected BMPs.

The blue, underlined text in this document represents a website link. If viewing this document in an electronic format, clicking on the link will take the user to the appropriate website. URL addresses are also provided for all referenced websites to accommodate users who are not viewing an electronic copy of this document. Typing the URL address into an internet browsing application will direct the user to the appropriate website. For websites outside the Wyoming Department of Environmental Quality (WDEQ), the WDEQ is not responsible for the content or maintenance of those websites.

1.3 Choosing a BMP

The choice of a particular BMP or series of BMPs depends on many factors. Not all urban BMPs can remove both particulate and soluble pollutants. When evaluating and selecting a specific BMP, consideration should be given to local climate, expected pollutants and pollutant loads, site location, site topography, maintenance requirements, depth of and interaction with ground water, land availability, and installation costs. Some of the BMPs discussed in this manual may also require design and construction oversight by an engineer or other natural resource professional. Permits may also be required from local, state, or federal government for some types of BMPs. Appendix A includes a list of some of the major permitting agencies within the state and the types of permits they issue. Be certain to check with appropriate agencies during the planning process to determine permit or other regulatory requirements.

Specific BMPs may or may not always be appropriate for a particular site or situation, therefore, thorough research, planning, and design should always go into the selection and installation of any urban BMP. The Environmental Protection Agency's (EPA) Browse the National Menu of Best Management Practices website provides easy navigation to search for factsheets for various BMPs, allowing one to categorize and narrow the search for the most appropriate application. Several BMPs also have modification options that can make them more suited for particular conditions. In addition, installing more than one BMP in a series can overcome the drawbacks of any single method, while providing enhanced pollutant removal.

1.4 Urban Sources of Nonpoint Source Pollution

Unlike point source pollution, which can be traced back to a single defined source, nonpoint source pollution is caused by surface water runoff that is diffuse in nature and often widespread, making it difficult to assess the source of the problem. Nonpoint source pollution occurs when runoff from rainfall or snowmelt travels over and/or percolates through the ground and picks up contaminants. These contaminants are deposited into streams, lakes, rivers, and ground water. Nonpoint sources of pollution continue to be recognized as the nation's largest remaining cause of surface water quality impairments, and the 2012 Wyoming Integrated 305(b)/303(d) Report shows that the majority of surface water quality impairments in Wyoming are due wholly or in part to nonpoint source pollution. Urban runoff is unique, in that most of the pollutant sources come from nonpoint sources. However, the conveyances of urban runoff to the surface waters are generally point sources.

Urban nonpoint sources of pollution commonly include sediment from construction sites, metals and other contaminants washed from streets or parking lots, fertilizers or pesticides washed from lawns, pathogens from pet waste, and toxic compounds from improperly disposed of hazardous materials (see also Table 1). Generally, in urban environments, pollutants accumulate on impervious surfaces between rainfall events or before snow melt. Then, when it rains or when the snow melts, there is a sudden concentrated introduction of pollutants into lakes, rivers, wetlands, and ground water. This occurrence is commonly known as the first flush effect. During storm and snow melt events, urban runoff often becomes a point source because storm sewers, which are not connected to wastewater treatment plants, collect the runoff and convey it directly to surface waters. Urban centers in Wyoming are typically located near surface water. In most cases, there are one or more surface water bodies (streams, rivers, ponds) flowing through or proximal to our cities. Protecting these surface waters is a major challenge and becomes more critical as cities and rural areas experience population growth and as the amount of impervious surface increases in areas that were historically open spaces.

1.5 Storm Water Regulations and Permitting

In 1972, the federal CWA was amended to provide that the discharge of any pollutants to surface waters of the United States had to be regulated through the issuance of a National Pollutant Discharge Elimination System (NPDES) permit. Under the CWA, the states were given the authority to assume "primacy" for the issuance of such permits and Wyoming obtained that primacy in 1974. Congress added section 402(p) to the CWA in 1987 to establish a comprehensive framework for addressing stormwater discharges under the WYPDES (Wyoming Pollutant Discharge Elimination System) program. On November 16, 1990, the Environmental Protection Agency (EPA) published regulations requiring that a WYPDES permit be obtained for all stormwater discharges associated with industrial facilities, including large construction projects where five or more surface acres are disturbed. The original 1990 regulation also covered municipal (i.e. publicly-owned) separate storm sewer systems (MS4s) for municipalities with populations over 100,000 (Phase I). In 1999, this regulation was expanded to include smaller municipalities (urbanized areas with population 50,000 or more) as well (Phase II). In addition, the EPA published additional regulations in 1999 requiring WYPDES permit coverage for stormwater discharges from small construction activities. Small construction activities are those that disturb at least one acre, but less than five acres.

There are no Phase I MS4s in Wyoming. However, there are at this time, two urbanized areas in Wyoming, as defined by the Census Bureau, where municipal, county, and other publicly-operated Phase II MS4s are required to be covered under a general stormwater permit. These cities include Cheyenne and Casper, and their associated urbanized areas. The main requirement of an MS4 general permit will be for the MS4 operator to develop and implement a stormwater management plan covering six minimum elements, or minimum control measures (MCMs). These measures are:

- Public education and outreach
- Public participation and involvement
- Illicit discharge detection and elimination
- Construction site stormwater runoff control
- Post-construction stormwater management in new development and redevelopment
- Pollution prevention and good housekeeping for municipal operations

WYPDES stormwater regulations are found in the Wyoming Water Quality Rules and Regulations, Chapter 2. In addition, the WYPDES Storm Water Program website provides information about WYPDES permitting of stormwater discharges, including additional details about MS4 general permits. The WYPDES Storm Water Program can be contacted at (307) 777-7781.

1.6 Urban Best Management Practices and Section 319 Funding

The Wyoming Nonpoint Source Program manages CWA Section 319 grant funding for the state. The purpose of Section 319 funding is to implement projects that reduce nonpoint source pollution to surface water and ground water. Projects that implement urban BMPs to reduce nonpoint source pollution may be eligible for Section 319 funding. However, Section 319 funding cannot be used to fund activities required under a WYPDES permit or other regulatory mechanism. Furthermore, Section 319 funds cannot be used to conduct activities that assist with securing or complying with a WYDPES permit. The Wyoming Nonpoint Source Program and WYPDES Stormwater Program will work together to ensure that there is no overlap between 319 funded projects and WYPDES permitting requirements on proposed urban BMP projects.

Per the EPA's *Nonpoint Source Program and Grants Guidelines for States and Territories* issued in the Federal Register on October 23, 2003, Section 319 funds may be used for urban stormwater activities that are not specifically required by a WYPDES stormwater permit. This includes activities on urban stormwater discharges that are not addressed by Phase II stormwater program requirements. This also includes aspects of Phase II that support but do not directly implement activities required by Phase II permits. In other words, activities that go above and beyond Phase II permit requirements could be eligible for Section 319 funding.

1.7 Importance of Local Government

Local development plans, ordinances and regulations may also play a role in stormwater management planning for urban areas. Plans or regulations may encourage or mandate methods that reduce or prevent environmental contamination from urban runoff, such as the treatment of runoff from construction sites or impervious areas or limits to the amount of allowable impervious area on a given lot size. Zoning requirements may also be modified, if necessary, to allow residential development styles that reduce impervious areas and increase green space. The Wyoming Nonpoint Source Program is committed to working with local governments to assist in identifying water quality problems and implementing workable, cost-effective solutions.

In addition, local government agencies, including cities, towns, and counties, and conservation districts, are excellent resources for assistance with understanding, planning, and implementing urban BMPs. The Wyoming Association of Municipalities can be contacted for assistance with locating and contacting municipal governments. The Wyoming County Commissioners Association can be contacted for assistance with locating and contacting county governments. Appendix B provides contact information for the Wyoming Association of Municipalities, the Wyoming County Commissioners Association, and local conservation districts.

1.8 Urban BMPs Not Included in this Manual

This manual focuses on those urban BMPs that will be considered for Section 319 funding in Wyoming. As described above, Section 319 funds cannot be used for urban BMP activities that are required through a permit or other regulatory mechanisms. Urban BMPs that are involved with basic municipal infrastructure for stormwater management, such as drain systems, are generally not eligible for Section 319 funding. In addition, BMPs designed to temporarily control runoff from construction sites are not included in this manual, as stormwater runoff from construction activities is regulated through the WYPDES program.

This, however, is not meant to undermine the importance of construction BMPs. Runoff from construction sites in urban areas is believed to be a major contributor of pollutants, primarily sediments. There are many BMPs that are designed to be temporary in nature to assist with controlling urban runoff on construction sites. For example, erosion control can be achieved through BMPs such as geotextile use, mulching, soil roughening, and seeding. Runoff control uses BMPs such as check dams and grass-lined channels. Sediment control uses BMPs such as fiber rolls, silt fences, and sediment traps. Because stormwater runoff from construction activities is covered under the WYPDES permitting program, BMPs designed to be temporary in nature for construction activities are not able to receive Section 319 funding. Thus, while they are important BMPs, they are not listed in Section 2 of this document. For questions about construction BMPs in Wyoming, please contact the WYPDES Stormwater Permitting Program at (307) 777-7781 or refer to the WYPDES Storm Water Program website. In addition, the WDEQ notes the following references as good information sources for construction BMPs:

> A Guide to Temporary Erosion-Control Measures for Contractors, Designers and Inspectors. 2001. North Dakota Department of Health Division of Water Quality. http://www.ndhealth.gov/wq/WasteWater/pubs/BMPManual.pdf

Chapter 6: Erosion Prevention and Sediment Control. *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota.* 2000. Minnesota Pollution Control Agency.
http://www.pca.state.mn.us/index.php/view-document.html?gid=7157

Construction Site Stormwater Runoff Control. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=4

Erosion and Sediment. 2011. Storm Water Management. City of Casper.
http://www.casperwy.gov/WaterSewerandTrash/StormWaterManagement/ErosionandSediment/tabid/531/Default.aspx

Erosion and Sediment Control Measures (ESCM). IIHR. Iowa Stormwater Partnership.
http://iowacedarbasin.org/runoff/escm1.htm

Volume 2: Erosion and Sediment Controls. *Catalog of Stormwater Best Management Practices for Idaho Cities and Counties.* 2005. Idaho Department of Environmental Quality Water Quality Division.
http://www.deq.idaho.gov/media/622263-Stormwater.pdf

Stormwater Control: Implementing Construction Site BMPs in the Northern Rocky Mountains. 2011. Montana Water Center.
http://watercenter.montana.edu/training/stormwater/stormwater_training.htm

Table 1 - Pollutants Typically Found in Urban Runoff*

COMMON URBAN RUNOFF POLLUTANT	SOURCE	AVERAGE CONCENTRATE	NONPOINT SOURCE IMPACTS
Sediment	Urban/ Suburban	80 mg/l Average	Fills in ponds and reservoirs with mud; contributes to decline of submerged aquatic vegetation by increasing turbidity and reducing the light available for photosynthesis, and covers or reduces spawning beds. Acts as a sink for nutrients and toxicants and as a source when disturbed and resuspended.
Total Phosphorus	Urban/ Suburban	1.08 mg/l 0.26 mg/l	A contributing factor cited in eutrophication (nutrient over-enrichment) in receiving water bodies and subsequent algal blooms. Algal blooms contribute to the decline of submerged aquatic vegetation by reducing light available for photosynthesis, further degrade water quality by decreasing the level of dissolved oxygen (DO), increase Biological Oxygen Demand (BOD), and may cause changes in the composition of plankton and fish species.
Total Nitrogen	Urban/ Suburban	13.6 mg/l 2.00 mg/l	Like total phosphorus, contributes to eutrophication and algal blooms, though more typically in salt water bodies.
Chemical Oxygen Demand(COD)	Urban/ Suburban	163.0 mg/l 35.6 mg/l	Decreases the concentration of dissolved oxygen (DO). Low DO concentration and anaerobic conditions (complete absence of DO) can lead to fish kills and unpleasant odors. Primarily released as organic matter in the "first flush" of urban runoff after storm.
Bacteria	Urban/ Suburban	Avg.-200 to 240,000 MPN/L	High concentrations can lead to aquifer contamination and closure of shellfish harvesting areas and prevent swimming, boating, or other recreational activities.
Zinc	Urban/ Suburban	0.397 mg/l 0.037 mg/l	Chronically exceeds EPA water quality criteria. Many fish species highly sensitive to zinc. Primary cultural source is the weathering and abrasion of galvanized iron and steel.
Copper	Urban/ Suburban	0.105 mg/l 0.047 mg/l (Nationwide Avg.)	Chronically exceeds EPA water quality criteria. Primary cultural source is as a component of anti-fouling paint for boat hulls and in urban runoff, from the leaching and abrasion of copper pipes and brass fittings. An important trace nutrient, it can bioaccumulate and thereby create toxic health hazards within the food chain and increase long term ecosystem stress.
Lead	Urban/ Suburban	0.389 mg/l 0.018 mg/l	Lead from gasoline burning in automobiles is less of a problem today because of unleaded gasoline use. However, lead from scraping and painting bridges and overpasses remains. Chronically exceeds EPA water quality criteria. Attaches readily to fine particles that can be bioaccumulated by bacteria and benthic organisms while feeding. Lead has adverse health impacts when consumed by humans.
Arsenic	Urban/ Suburban	Avg. 6.0 µg/l	An essential trace nutrient. Can be bioaccumulated; creates toxic health hazards within the food chain and increases long term stress for the ecosystem. Accumulates within tidal, freshwater areas, increasing the toxicity for spawning and juvenile fish. Primary cultural source is fossil fuel combustion.
Cadmium	Urban/ Suburban	Avg. 1.0 µg/l	Primary cultural source is metal electroplating and pigments in paint. Can be bioaccumulated; creates toxic health hazards within the food chain and increases long-term toxic stress for the ecosystem.
Chromium	Urban/ Suburban	Avg. 5.0µg/l	Primary cultural source is metal electroplating and pigments in paint. Can be bioaccumulated; creates toxic health hazards within the food chain and increases long-term toxic stress for the ecosystem.
Pesticides	Urban/ Suburban	Avg. <0.1 µg/l	Primary urban source is runoff from home gardens and lawns. Can bioaccumulate in organisms and create toxic health hazards within the food chain. Also has been found as a contaminant in aquifers.
Oil and Grease	Urban/ Suburban	Avg. 2-10 mg/l	Toxicity contributes to the decline of zooplankton and benthic organisms. Accumulates in the tissues of benthic organisms; a threat to humans when consumed directly or when passed through the food chain. Primary cultural source is automobile oil and lubricants.

***Based on mid-Atlantic Coast data. Source: Terrene Institute, 1994.

Section 2: Urban Best Management Practices

There are many types of BMPs designed to reduce pollution caused by urban runoff. As discussed in Sections 1.5 – 1.6, some urban BMP activities are managed under the WYPDES permitting program and other urban BMP activities, which are not under a regulatory mechanism, are potentially eligible for federal CWA Section 319 funding. Construction BMPs, while important, are not included on this list since they are covered under the WYPDES program (see Section 1.8). The following is a list of the urban BMPs that the Wyoming Nonpoint Source Program will consider for CWA Section 319 funding. The following is not intended to be a comprehensive list of all urban BMPs currently available. Please note that inclusion of a BMP in this manual does not guarantee Section 319 funding for that BMP. The Wyoming Nonpoint Source Program and Nonpoint Source Task Force will recommend funding for BMP implementation projects on a project-by-project basis, and will take into consideration the advantages and limitations of proposed BMPs to evaluate the most efficient and cost-effective solutions possible.

2.1 Detention Facilities

Some urban BMPs are designed to detain and store stormwater runoff. Capturing and detaining stormwater runoff helps to control peak discharge rates, thereby minimizing effects of flooding. Detention facilities can also be designed to treat stormwater in addition to providing flood control. Detention BMPs primarily come in the form of stormwater ponds, although simpler BMPs, such as rain barrels and cisterns, also operate through detention, but on a much smaller scale.

Stormwater ponds are the most commonly used detention BMP and can be designed to manage both the quantity and quality of urban runoff. Stormwater ponds gradually release stored water at a controlled rate to a downstream waterbody through an outlet structure. By storing runoff during peak discharge events and then releasing water at flow rates and frequencies closer to natural hydrologic conditions, stormwater ponds can help reduce channel erosion, and prevent sediment loading into downstream waterbodies. In addition, stormwater ponds can be designed to promote physical settling of sediments and the pollutants associated with sediment, such as trace metals, nutrients, and hydrocarbons. Depending on their design, stormwater ponds may also provide additional pollutant treatment through biological or chemical processes, which can be effective at removing oxygen-demanding substances, bacteria, and dissolved nutrients.

Detention ponds can be designed as “dry ponds” which do not have a permanent pool of water and are dry between storm events. Dry ponds are primarily used for flood control and have little ability to treat water quality unless they are designed to extend the time that the water is detained and thus allow time for pollutant settling. Such facilities are known as dry extended detention ponds, and they can be an effective BMP. Even more effective as a BMP, however, are “wet ponds”, which are detention ponds that have a permanent pool of water. The presence of a permanent pool of water helps dissipate the energy of incoming discharges, which reduces scour and the potential for resuspension of sediment. Pollutant removal is enhanced in wet ponds due to the presence of terrestrial vegetation, aquatic vegetation, and microbes that treat pollutants through biological and chemical processes. Wet extended detention ponds incorporate the flood control aspect of a dry extended detention pond with the water quality treatment of a permanent pool. A final type of detention pond, the stormwater wetland, involves the construction of a shallow wet detention pond that is designed to maintain permanent marsh vegetation. Wetland vegetation, algae, and microbes work to enhance pollutant removal.

A planner or engineer is not limited to using only one type of stormwater pond. In many cases it may be appropriate to use multiple techniques within one pond or utilize multiple ponds in a series. Doing so can help a planner design BMPs most appropriate for a given site and help overcome limitations presented by any one BMP type and improve overall effectiveness and reliability. To enhance performance, detention pond designs will often include a sediment forebay at the inlet and a micropool or plunge pool at the outlet. In addition, combinations of different types of detention ponds can be utilized in a series together to maximize pollutant removal. This use of more than one pond treatment system in a cluster or series is commonly referred to as a multiple pond system.

The following BMP factsheets provide information on some of the most common detention BMPs for urban runoff. Other urban BMPs that function using detention as the mechanism for pollutant control will be evaluated on a case-by-case basis for funding by the Wyoming Nonpoint Source Program.

BMP 1: Dry Detention Ponds

Photo of a dry detention pond. Source: NPDES

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids	●	●	
Nitrogen	●		
Phosphorous	●	●	
Metals		●	
Bacteriological	●		
Hydrocarbons	●		

Source: Iowa Stormwater Management Manual

Description: Dry detention ponds (a.k.a. dry ponds, extended detention basins, extended detention ponds) are stormwater basins designed to provide temporary storage of stormwater runoff. Dry ponds detain a portion of the runoff for some minimum time after a storm using a fixed outlet. They are generally designed to completely empty out between storm events and do not normally have any permanent standing water.

The primary purpose of most detention ponds is flood control. Dry ponds are installed to reduce the peak discharge of stormwater to streams, therefore, reducing and controlling downstream flooding and providing some degree of channel protection. In addition, they also are capable of some pollutant removal, which is accomplished mostly through gravitational settling. The amount of settling varies with the amount of detention time.

Along with a detention area, enhanced dry extended detention ponds can include a sediment forebay near the inlet and a micropool or plunge pool at the outlet (Figure 2). This enhanced design can prevent clogging and resuspension of sediments and increase detention time, therefore, allowing more physical settling of pollutants.

Feasibility: Dry detention ponds can be used as retrofit practices or in combination with micropools, wetlands or permanent pools. Dry ponds are most often utilized in low visibility development areas and may not be appropriate in high visibility residential or commercial areas. Space constraints may also prevent their use in highly urbanized areas. In addition, at sites where bedrock is close to the surface, high excavation costs may make dry ponds infeasible. However, dry pond systems are known to perform well in cold climates due to flexible modification options.

To increase effectiveness, ponds should be placed at locations where they can intercept the most amount of runoff from a site. These locations are generally found in the areas with the lowest elevation. The contributing watershed area should be at least 10 acres.

Maintenance: Routine mowing should be done at least twice annually, but may need to be performed more frequently if aesthetics are an issue. In addition, trash and debris should be removed at least twice during the growing season, and pond outlet devices should be monitored for clogging and unclogged if necessary.

Generally, removal of accumulated sediment should be performed once every 5-10 years or when the sediment volume exceeds 10 percent of the basin volume.

BMP 1: Dry Detention Ponds

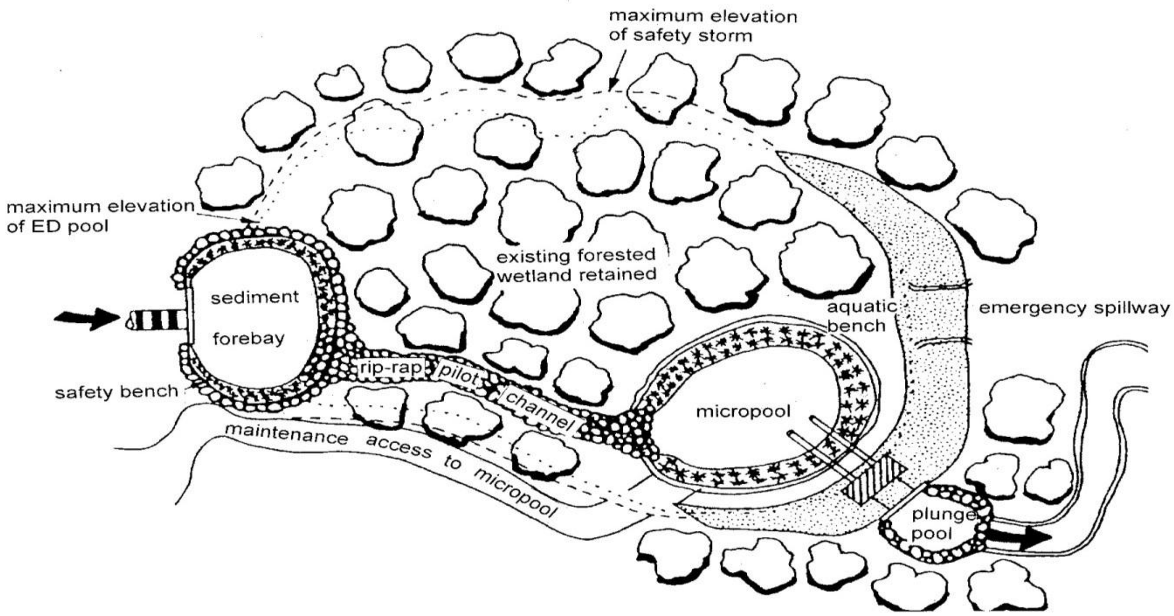

Figure 1. Schematic design of an enhanced dry extended detention pond system. Source: Schueler, 1991

Advantages:

- Relatively easy and inexpensive to construct and operate
- Effective for controlling peak discharges, which helps prevent channel erosion, sediment loading, and loss of aquatic habitat of receiving streams
- Can perform well in cold climates
- Less hazardous than other stormwater quality ponds with deeper permanent pools
- Widely applicable and can be applied in all regions of the United States
- Good retrofitting option for existing basins
- Can be used in combination with other stormwater control practices, such as wetlands or wet ponds, and can provide good streambank erosion protection and stormwater treatment when used in combination
- Can be used for recreational areas during dry periods between storm events

Limitations:

- Generally not prescribed for drainage areas less than 10 acres
- Provide only moderate pollutant removal and are relatively ineffective at soluble pollutant removal unless combined with a permanent pond
- Discharge of warmer, stored water from the pond can raise the temperature of downstream receiving waters, and therefore, their use should be limited in areas that are ecologically sensitive to temperature changes
- Use in highly developed areas is fairly limited due to space constraints

BMP 1: Dry Detention Ponds

Limitations continued:

- Sometimes considered unattractive by residents and can potentially decrease home and property value
- Sediments can be resuspended if not removed between storm events
- Potential for mosquito breeding and other insect nuisances if pond does not drain adequately between storm events

References:

The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

2G Detention Practices: 2G-2 Dry Detention. *Iowa Stormwater Management Manual*. 2009. Iowa State University.
http://www.intrans.iastate.edu/publications/_documents/handbooks-manuals/storm-water/Design/2G/2G-2%20Dry%20Detention.pdf

Detention Systems: Dry Ponds. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. 2001. Prepared for the Metropolitan Council.
http://www.metrocouncil.org/environment/water/BMP/CH3_STDetDryPond.pdf

Dry Detention Basin. *Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook.* 108-111.
http://www.mass.gov/dep/water/laws/v2c2.pdf

Dry Detention Ponds. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency.
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=67

Extended Dry Detention Basin. *Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook.* 49-53.
http://www.mass.gov/dep/water/laws/v2c2.pdf

Retention Systems: Extended Storage Ponds. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. 2001. Prepared by Barr Engineering Co. Prepared for the Metropolitan Council.
http://www.metrocouncil.org/environment/water/BMP/CH3_STRetenExtended.pdf

TC-22 Extended Detention Basin. *California Stormwater BMP Handbook: New Development and Redevelopment.* 2003. California Stormwater Quality Association.
http://www.cabmphandbooks.com/Documents/Development/TC-22.pdf

BMP 2: Wet Detention Ponds

Photo of a wet detention pond. Source: NPDES

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids		●	●
Nitrogen		●	
Phosphorous		●	
Metals		●	
Bacteriological			●
Hydrocarbons		●	

Source: Iowa Stormwater Management Manual

Description: Wet ponds (a.k.a. wet retention ponds, stormwater ponds) are detention ponds that have a permanent pool of water throughout the year. Wet detention ponds control both stormwater quantity and quality by capturing and retaining runoff during storm events. Pollutants are primarily removed through physical settling in the permanent pool. Similar to dry ponds, the amount of pollutant removal through settling corresponds with the amount of detention time. In addition, some uptake of pollutants can occur through biological activity in the pond.

In general, wet ponds provide better stormwater quality control and nutrient removal than other detention BMPs, and there are several modifications that can be made to increase their effectiveness. For example, Figure 3 displays an enhanced designed that includes a sediment forebay to catch the heavier sediments, along with a fringe wetland around the perimeter of the pond to promote pollutant removal by biological uptake. A vegetation buffer around the perimeter of the pond or peripheral vegetative ledges throughout the pond can also help decrease water temperature, prevent bank erosion, and slow the water flow rate.

Wet ponds can be designed to increase the detention time and thereby, time available for pollutant removal, by maximizing the length of the flow path through the pond. Using multiple ponds in a series can also increase efficiency by increasing detention time and decreasing flow rate. For example, when dry and wet ponds are utilized together, the flood control capabilities of dry ponds and pollutant removal effectiveness of wet ponds are combined. Generally, with this combination, runoff is stored in an upper dry detention pond and then slowly released into a lower wet pond.

Feasibility: Wet detention ponds are occasionally used for stormwater retrofits and often used in combination with wetlands or dry ponds. Wet ponds are one of the most widely used stormwater practices. They are applicable in most regions, but can be infeasible at sites where bedrock is close to the surface due to high excavation costs. In addition, wet ponds can be limited in areas with highly arid climates where evapotranspiration significantly exceeds precipitation. Cold climates can also cause slight declines in their performance due to freezing and high salt and sediment concentrations in winter runoff, which can adversely affect pond vegetation as well as reduce the pond’s storage and treatment capacity. However, although this BMP can have limitations in arid or semi-arid, colder regions, it can still be successfully implemented in these areas with careful planning, design, and examination of the available water resources.

BMP 2: Wet Detention Ponds

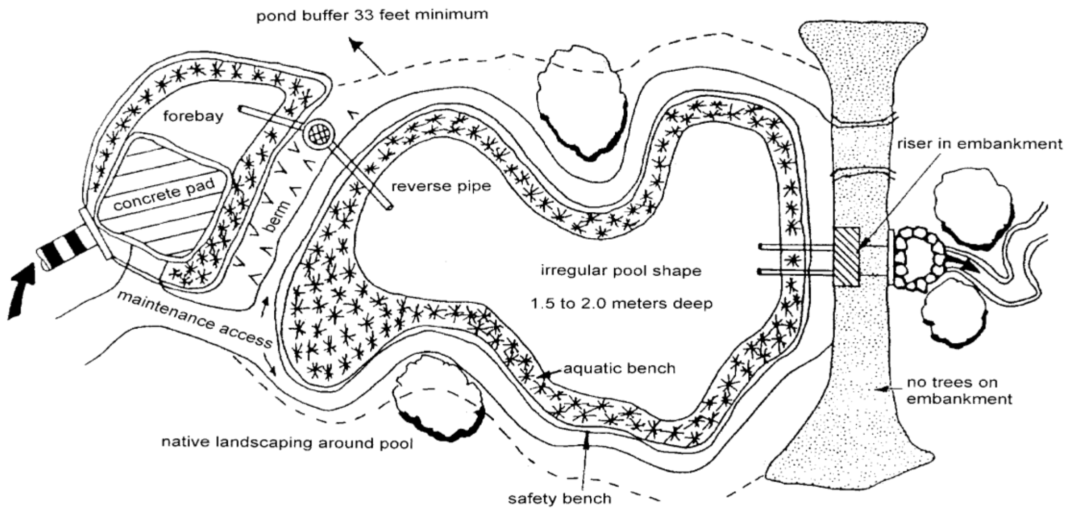

Figure 2. Schematic Design of an Enhanced Wet Pond System. Source: Schueler, 1991

Feasibility continued: Wet ponds can be more aesthetically pleasing, and therefore, can be utilized in both low and high visibility development areas. Space constraints may prevent their use in highly urbanized areas, but wet ponds can provide an urban amenity if space is available. Construction costs can range considerably, and contributing watershed areas for wet ponds should be greater than 10 acres but less than 1 square mile.

Maintenance: In general, maintenance considerations for a wet pond include semiannual inspections, mowing, managing vegetation, removal of sediment, trash and debris, erosion repair, and management of mosquito breeding and invasive species.

The amount and frequency of routine maintenance required for a wet pond varies upon pond location and visibility and local regulatory agencies. For example, the frequency of routine mowing and the removal of trash and debris may increase if the pond is located at a highly visible and publicly utilized site. In addition, health and vector control agencies are often concerned about mosquito breeding and may require more maintenance for mosquito breeding control measures, and although not recommended, if chemical means are necessary for mosquito control, they should be utilized in a safe manner that does not lead to further contamination of the water.

Advantages:

- One of the most effective BMPs for both flood control and pollutant removal if properly designed and located
- Capable of moderate to high removal of both solid and soluble urban pollutants; can provide significant water quality improvement
- Can be designed for flood control; controlling peak discharges and helping prevent channel erosion and sediment loading into downstream receiving waters
- Widely applicable and can be applied to most regions of the United States
- Can create aquatic and terrestrial wildlife habitat
- High community acceptance; can increase property value if properly constructed

BMP 2: Wet Detention Ponds

Advantages continued:

- Can provide aesthetic and recreational value and become viewed as a public amenity when integrated into a park setting
- Can be used in combination with other stormwater control practices, such as wetlands or dry ponds, and can provide good streambank erosion protection and stormwater treatment when used in combination

Limitations:

- Generally not prescribed for drainage areas smaller than 10 acres
- Improperly designed or unmaintained ponds can cause re-suspension of solids and anoxic conditions that can promote the re-release of pollutants
- Discharge of warmer, stored water from the pond can raise the temperature of downstream receiving waters, and therefore, their use should be limited in areas that are ecologically sensitive to temperature changes
- Cannot be placed on steep unstable slopes
- Cold climates can reduce the wet pond's pollutant removal efficiency
- Use in highly developed areas is fairly limited due to space constraints
- Concern for creating potential breeding habitat for mosquitos
- Concern for potential bacterial contamination from excessive waterfowl visitation

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The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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BMP 3: Stormwater Wetlands

Photo of a stormwater wetland. Source: Iowa Stormwater Management Manual

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen		●	
Phosphorous	●	●	
Metals		●	●
Bacteriological		●	●
Hydrocarbons			●

Source: Iowa Stormwater Management Manual

Description:

Stormwater wetlands (a.k.a. constructed wetlands) are constructed wetland systems that are designed to maximize the removal of pollutants from stormwater runoff through settling and vegetation uptake. Stormwater wetlands differ from wet ponds in that they are shallower in depth, and therefore, create conditions suitable for the growth of wetland plants throughout.

Constructed wetlands are one of the most effective stormwater practices for pollutant removal and can be combined with other BMP detention pond systems or with other BMP components, such as a sediment forebay and a micropool, to increase effectiveness (Figure 4). Wetlands remove pollutants through gravitational settling, plant uptake, adsorption, physical filtration and microbial decomposition. Wetland treatment can be very effective for removing bacteria, sediment, trace metals, nutrients, hydrocarbons, and other oxygen-demanding substances. In addition, wetlands can provide aesthetic value and habitat creation.

Stormwater wetlands are constructed systems, and a distinction should be made between them and natural wetlands. The diversion of stormwater runoff into natural wetlands is not recommended due to the potential negative ecological impacts. Stormwater wetlands are not made with the intention to replicate all the ecological functions of a natural wetland.

One newly developed treatment system, referred to as floating treatment wetlands, utilizes the pollutant removal mechanisms of wetland plants, but does not require new land and can be used in existing water bodies of any depth or sizes. Floating treatment wetlands are constructed floating islands that are vegetated with wetland plants. Roots extend directly into the water body, thereby increasing the exposed root surface area and enhancing the plants' nutrient uptake ability. Floating wetlands have been found to be highly effective for nutrient removal, can provide additional wildlife habitat, and can be used in conjunction with or as an alternative for constructed wetlands.

Feasibility:

Constructed wetlands are applicable in most regions of the United States, with the exception of a few possible site constraints. Site constraints that can limit the applicability of stormwater wetlands include arid climate conditions, inappropriate soil types, depth to ground water, contributing watershed area and available land. Similar to feasibility limitations of wet and dry ponds, at sites where bedrock is close to the surface, high excavation costs may make the ponds infeasible.

BMP 3: Stormwater Wetlands

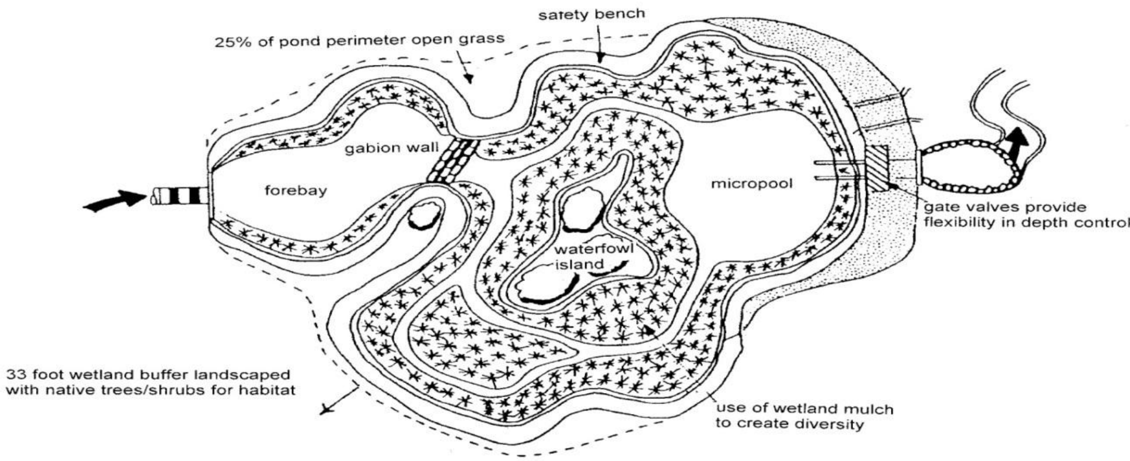

Figure 3. Schematic design of an enhanced shallow march system. Source: Schueler, 1991

Feasibility continued: Space constraints can also limit the use of stormwater wetlands in highly developed areas, but the use of "pocket wetlands" or floating islands has been successful in areas where land is limited. Generally, the contributing watershed area should be greater than 10 acres. Medium-fine texture soils (such as loams and silt loams) are best for establishing a highly functional stormwater wetland system. However, impermeable liners can be used at sites with inappropriate soil conditions, such as areas with sandy soils where infiltration is too rapid to sustain permanent soil saturation.

Maintenance: Stormwater wetlands require routine maintenance. To effectively establish a functional marsh, constructed wetlands require frequent maintenance in the first three years. During this time, semiannual inspections are necessary to observe the types and distribution of dominant wetland plants, the presence and distribution of invasive wetland species, and percentage of unvegetated standing water. After the second growing season, wetland vegetation should be managed to maintain at least 50% surface area coverage. Wetlands should also be inspected for invasive vegetation semiannually, and the invasive species should be removed where possible.

Sediment accumulation should be monitored and removed periodically, as sediment buildup can result in reduced water depth and alter growing conditions. If a sediment forebay is included, frequent sediment removal from the forebay is recommended to prevent accumulation in the constructed wetland.

Advantages:

- High pollutant removal efficiency for soluble pollutants and particulates; one of the most effective stormwater practices in terms of pollutant removal
- Can reduce oxygen-demanding substances and bacteria from urban runoff
- Can provide great amounts of biological uptake of nutrients by wetland plants
- Can reduce peak discharges and flood attenuation; helping prevent downstream channel erosion and sediment loading
- Provide aesthetic and potential recreational value to the community; can be used as a source of public education about wetlands and their benefits
- Can enhance vegetation diversity and create aquatic and terrestrial habitat

BMP 3: Stormwater Wetlands

Limitations:

- Can be difficult to maintain vegetation under various flow conditions
- Can release some nutrients in the fall and winter months
- Discharge of warmer, stored water from the wetland can raise the temperature of downstream receiving waters, and therefore, their use should be limited in areas that are ecologically sensitive to temperature changes
- Relatively larger land requirements and higher construction costs than other BMPs
- Concern for creating potential breeding habitat for mosquitos
- Use in highly developed areas is fairly limited due to space constraints
- Improper siting can negatively affect natural wetlands and forest lands
- Possible bacterial contamination if waterfowl population become dense

References:

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2.2 Infiltration and Filtration Facilities

Some BMPs are designed to operate primarily through filtration and infiltration to manage stormwater runoff. Filtration and infiltration techniques use the basic method of filtering runoff through some sort of medium to achieve pollutant and sediment removal. The two practices vary slightly from one another, in that infiltration methods often allow water to percolate and infiltrate through the subsoils and provide ground water recharge. Filtration methods are generally more contained and consist of an impermeable liner and an underdrain system that prevent soil infiltration by capturing and directing treated runoff to a conveyance system or another treatment system. However, most filtration and infiltration devices can be designed to include or not include an impermeable liner and underdrain, depending on factors such as the pollutant loads, whether ground water contamination is a concern, or if ground water recharge is desired.

Infiltration and filtration BMPs are generally designed to intercept stormwater runoff and filter it through some constructed medium before the water exfiltrates to the subsoil or is conveyed elsewhere by the underdrain. Some practices use natural mediums, such as grass or other native vegetation, to initially filter stormwater runoff. Infiltration basins, bioretention systems, grassed swales, vegetated filter strips, green roofs, and native landscaping all utilize vegetation to help remove pollutants through straining, plant uptake, and other biological processes. Infiltration trenches and permeable pavement systems use stone, aggregate, or permeable asphalt or concrete to initially filter stormwater runoff before it exfiltrates to the soil or is conveyed by an underdrain system.

Filter systems, such as media filters, generally use sand, organic material, or a combination of mediums, to filter stormwater runoff. In addition, these filter systems often include a pretreatment component that captures course sediment before the water reaches the filtration media. This pretreatment is essential for media filters, as without it, the course sediment would quickly clog the filter medium. Media filtration practices are generally contained systems that include an impermeable liner and underdrain that prevent exfiltration. This makes them useful for areas with highly contaminated runoff. However, as mentioned previously, if ground water contamination is not an issue and ground water recharge is desired, filtration systems can be designed without an underdrain system to allow treated water to filter through the subsoils.

When stormwater percolates through the subsoil, additional chemical, physical, and biological processes occur to help remove pollutants. Adsorption, straining, microbial decomposition, and plant uptake are a few of these processes that aid with pollutant removal in the soils. Most infiltration and filtration BMPs can provide ground water recharge, as the water that percolates through the subsoil will eventually be directed to ground water. This method can also help preserve the baseflow of nearby streams.

Several infiltration and filtration BMPs can also be very useful in highly urbanized areas, as they can be designed to take up little to no new permeable land. For example, permeable pavement systems serve as good alternatives for conventional pavement and can be used as a stormwater retrofit for existing paved areas. In addition, green roofs can be constructed on existing roof tops, and native landscapes can replace existing landscapes. Sand and organic filters can also be constructed as underground systems if space is limited.

While infiltration and filtration BMPs generally have high treatment efficiency, it is critical that proper siting, design, construction, and maintenance be done to maximize effectiveness, avoid clogging problems, avoid accumulation of metals, and most importantly, avoid ground water contamination. It is essential for all infiltration and filtration BMPs to conduct thorough analysis and planning to prevent pollutants from reaching ground water. Infiltration and filtration practices may not be appropriate for all situations. Several of them are generally designed for smaller contributing drainage areas, not exceeding 5 acres. Areas with high sediment loads can often cause clogging, and the pretreatment of runoff is important to prevent clogging and to increase the longevity and effectiveness of these BMPs.

The following BMP factsheets provide information on some of the most common infiltration and filtration BMPs for urban runoff. Other urban BMPs that function using infiltration or filtration as the mechanism for pollutant control will be evaluated on a case-by-case basis for funding by the Wyoming Nonpoint Source Program.

BMP 4: Infiltration Trenches

Photo of an infiltration trench. Source: California Stormwater BMP Handbook

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen		●	●
Phosphorous		●	
Metals			●
Bacteriological			●
Hydrocarbons		●	

Source: Iowa Stormwater Management Manual

Description:

Infiltration trenches are shallow (3 to 12 feet) rock-filled excavations that serve as reservoirs for stormwater runoff. Infiltration trenches do not have any outlets and are often lined with filter fabric. Stormwater runoff is initially stored in the void space between the rocks then gradually percolates and infiltrates through the bottom and sides of the trench into the surrounding soil matrix.

Infiltration trenches can provide ground water recharge and pollutant control. The primary recharge and pollutant removal method of infiltration trenches is through soil filtration, which includes mechanisms such as adsorption, straining and microbial decomposition. Infiltration trenches have a high capability to remove particulate pollutants and a moderate capability to remove soluble pollutants.

Trenches are not intended for controlling coarse sediment or heavy concentrations of fine sediment because these materials can clog the trench. It is highly recommended that infiltration trenches be combined with other BMPs, such as sediment forebays or filter strips that treat stormwater runoff for sediments before entering the trench. The use of other BMPs in conjunction with infiltration trenches is recommended because trenches have limited capabilities for controlling peak discharges of runoff.

Feasibility:

The application of infiltration trenches is dependent upon site factors such as soil permeability, slope, depth to water tables, and size of drainage area. Due to frequent clogging, infiltration trenches are generally infeasible for areas with relatively impermeable soils or for areas that receive large sediment loads. The use of trenches may also be limited in areas where the ground commonly freezes or in areas where wind erosion may introduce a significant sediment load, but they can still be effective in these conditions if properly sited, designed, and maintained. In addition, ground water contamination can be an issue if trenches are too close to the water table level or if soils are too permeable, and therefore, they are often not suitable in areas with a shallow ground water table or areas with very coarse soils.

Trenches are most suitable to sites with gentle slopes, fairly permeable soils, deep bedrock, and deep ground water. Infiltration trenches are suitable for impervious areas where there are not high levels of sediment load in the runoff. Their thin profile makes them adaptable to many sites, and they are one of the few BMPs that can be relatively easy to fit into less-utilized areas of developed sites, making them ideal for retrofitting. However, the relatively poor infiltration capacity of urban soils may limit their applicability in some areas.

BMP 4: Infiltration Trenches

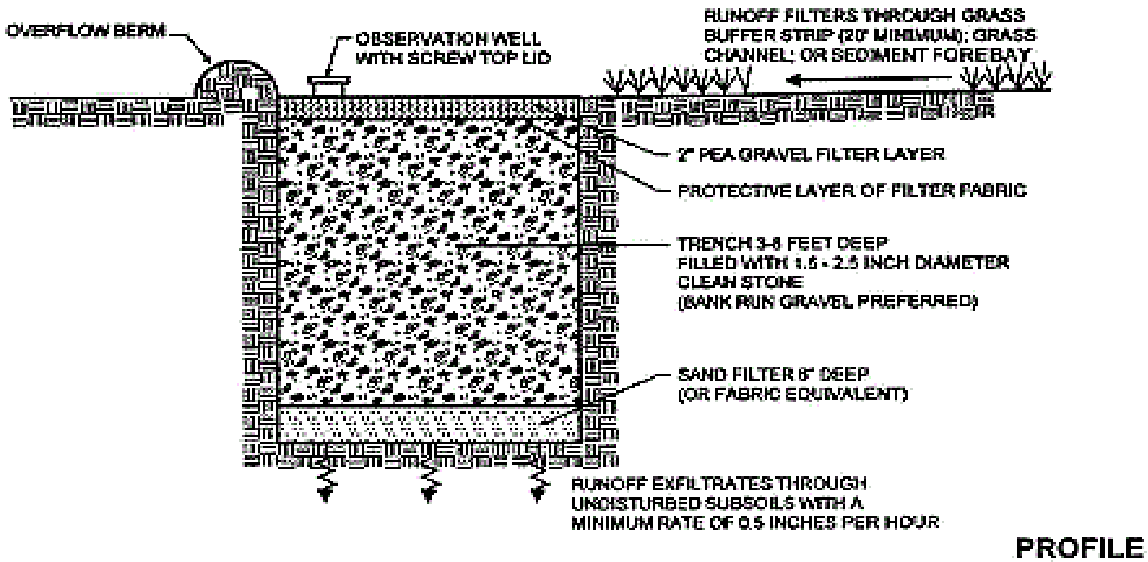

Figure 4: Schematic design of a conventional infiltration trench. Source: NPDES

Feasibility continued: Contributing drainage areas for infiltration trenches must be relatively small and not exceed 5 acres, and therefore, in terms of cost per area treated, can be somewhat expensive to implement. Infiltration trenches can be suitably used to control runoff from parking lots, rooftops, local roads, highways, and small residential developments.

Maintenance: Frequent maintenance of infiltration trenches is essential for the success and proper operation of the system. Since trenches are prone to failure due to clogging, it is necessary that aggressive, preventative maintenance be performed regularly. Using pretreatment BMPs in conjunction with the infiltration trench will significantly reduce the maintenance demands of the trench itself. Infiltration trenches should all eventually be rehabilitated, but regular maintenance can prolong their operational life.

Infiltration trenches should be inspected at least twice per year for accumulated sediment, leaves and debris, and clogging. If there is ponded water several days after a rain event, it is a good indicator that the trench may be clogged and corrective maintenance should be performed immediately. In addition, pretreatment BMPs that are incorporated into the trench system should be inspected, cleaned, and removed of sediment accumulation at least twice a year.

Advantages:

- Can provide ground water recharge and preserve baseflow in nearby streams
- Highly effective for pollutant removal when properly designed and maintained
- Can provide some reduction in downstream flooding and channel erosion
- Suitable in areas where space is limited; ideal for stormwater retrofits
- Appropriate and effective for small sites, such as parking lots, rooftops, and residential lots; can reduce local flooding
- Can reduce the amount of runoff from a given drainage area

BMP 4: Infiltration Trenches

Limitations:

- High failure rates if improperly sited, designed, or maintained; failure rate increases significantly if pretreatment BMP is not incorporated into the design
- Risk of ground water contamination may exist depending on soil conditions, land use in the watershed, and ground water depth; not recommended in industrial or commercial areas where potential of highly polluted surface runoff exists, in areas with shallow ground water tables, or in areas with coarse, highly permeable soils
- Susceptible to clogging by sediment
- Require frequent inspection and maintenance
- Restricted to smaller drainage areas that are less than 5 acres
- Construction costs are somewhat expensive in terms of cost per area treated

References:

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BMP 5: Infiltration Basins

Photo of an infiltration basin. Source: NPDES

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen		●	●
Phosphorous		●	●
Metals			●
Bacteriological			●
Hydrocarbons			●

Source: Iowa Stormwater Management Manual

Description: Infiltration basins are shallow (3 to 12 feet) stormwater impoundments that are designed to capture and temporarily store incoming stormwater runoff until it gradually infiltrates into the soil through the sides and flat bottom of the basin. Infiltration basins use natural soil filtration capabilities, such as adsorption, straining, and microbial decomposition, to remove pollutants from stormwater runoff.

When correctly sited, designed, constructed, and maintained, infiltration basins can be very effective treatment systems. They are capable of high pollutant removal efficiencies, can lead to ground water recharge, can reduce runoff volume, and can reduce peak discharges. However, due to the specific soil requirements, they can be relatively hard to apply.

Infiltration basins should not have permanent pools of water, and generally, drainage should occur within a minimum of 72 hours to maintain aerobic conditions and promote microbial removal of pollutants. Course sediment or high concentrations of fine sediment can clog the basin, lead to ponding, and take up storage volume. Therefore, it is recommended that infiltration basins be combined with pretreatment BMPs that will treat stormwater runoff for sediments before entering the basin. The use of other BMPs in conjunction with infiltration basins is recommended because basins have limited capabilities for controlling peak discharges of runoff for storms larger than that which they are designed for. It is also important to vegetate the bottom of the basin to increase the infiltration capacity, as roots provide small conduits for water to infiltrate and can help reduce soil erosion.

Feasibility: The application of infiltration basins is dependent upon site factors such as soil permeability, slope, depth to water tables, and size of drainage area. Due to frequent clogging, basins are generally not suited for areas with relatively impermeable soils or for areas that receive large sediment loads. Use of basins may also be limited in arid climates where wind erosion may introduce a significant sediment load or in regions with cold climates where the ground commonly freezes, however, they can still be effective in these conditions if properly sited, designed, and maintained.

Ground water contamination can also be an issue if basins are too close to the water table level or if soils are too permeable, and therefore, they are often not recommended in areas with a shallow ground water table or in areas with very coarse soils. In addition, runoff from highly contaminated areas should not be directed to infiltration basins unless previously treated.

BMP 5: Infiltration Basins

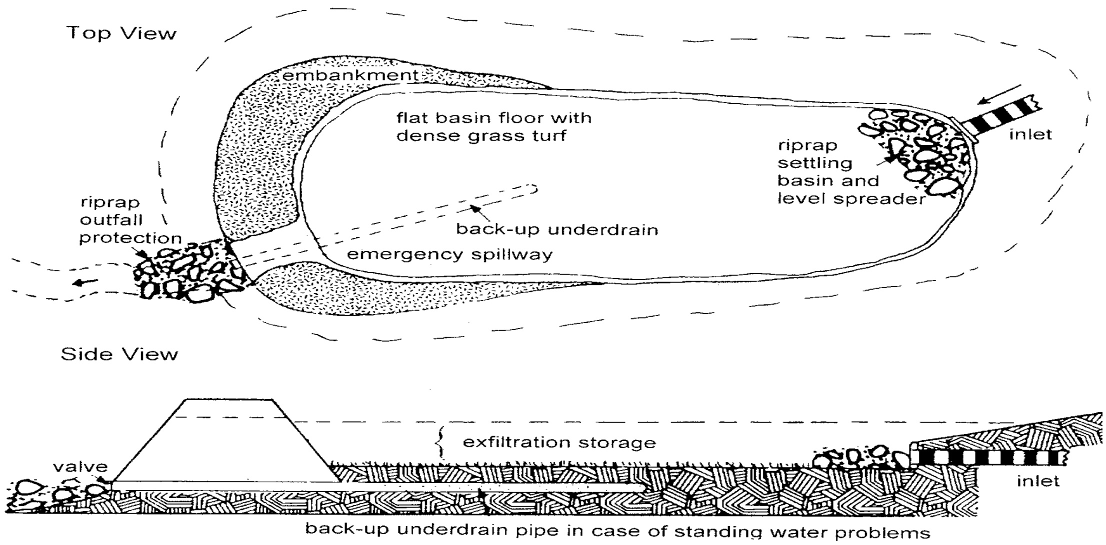

Figure 5: Schematic design of an infiltration basin. Source: Schueler, 1987

Feasibility continued: Infiltration basins are most suitable to sites with gentle or no slope, permeable soils, deep bedrock, and deep ground water levels, and are relatively cost-effective practices due to the little infrastructure necessary to construct them. However, due to space constraints and the relatively poor infiltration capacity of most urban soils, basins are not suitable for highly urbanized areas and relatively limited in their use as retrofits. The bottom of the basin should be completely flat to provide uniform ponding, and the contributing drainage area for infiltration basins should be between 2 to 15 acres.

Maintenance: Frequent maintenance of infiltration basins is essential for the success and proper operation of the system. Since basins are also prone to failure, it is necessary that aggressive, preventative maintenance be performed regularly. Using pretreatment BMPs in conjunction with the infiltration basin will significantly reduce the maintenance demand and increase the longevity of the basin itself.

Infiltration basins should be inspected at least twice per year and observed for accumulation of sediment, erosion of the basin floor, vegetation health, and adequate infiltration capability. Standing water residing more than 72 hours after a rain event indicates that the basin is clogged or that the basin’s infiltration capacity may have been compromised or incorrectly estimated. At least twice a year, the buffer area, side slopes, and basin bottom should be mowed and trash and debris should be removed from the basin. When the volume of sediment accumulation exceeds 10 percent of the basin, it should be removed using light equipment to avoid soil compaction. The sediment and basin floor should also be thoroughly dry when removing accumulated sediment. Revegetation and weeding should also be performed as necessary. As a last resort, infiltration basins can be converted into retention basins or wetlands if restoration is not possible.

Advantages:

- Highly effective for pollutant removal when properly designed and maintained
- Can provide ground water recharge and preserve baseflow streams
- Can provide some reduction of downstream flooding and channel erosion

BMP 5: Infiltration Basins

Advantages continued:	• Can reduce the amount of runoff from a given drainage area and can reduce local flooding • Do not cause warming of downstream waters and therefore, are a good option for areas with cold water streams • Relatively cost-effective due to the lack of infrastructure necessary to construct
Limitations:	• High failure rates if improperly sited, designed, or maintained; failure rate increases significantly if pretreatment BMP is not incorporated into the design • Risk of ground water contamination may exist depending on soil conditions, land use in the watershed, and ground water depth; not recommended in industrial or commercial areas where potential of highly polluted surface runoff exists, in areas with shallow ground water tables, or in areas with coarse, highly permeable soils • Susceptible to clogging by sediment; not appropriate for treating drainage areas with high sediment loads • Require frequent inspection and maintenance • Proper construction requires a continuous, flat, permeable area • Use in highly urban areas not recommended due to size constraints and compaction of urban soils
References:	The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites. 2E Infiltration Practices: 2E-3 Infiltration Basins. *Iowa Stormwater Management Manual*. 2009. Iowa State University. http://www.intrans.iastate.edu/publications/_documents/handbooks-manuals/storm-water/Design/2E/Part%202E%20-%20Infiltration%20Practices.pdf 4.63 Filtration Practices: Infiltration Basins. *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota. Chapter 4: BMPs for Stormwater Systems.* 2000. Minnesota Pollution Control Agency. http://www.pca.state.mn.us/index.php/view-document.html?gid=7155 Infiltration Basin. National Pollutant Discharge Elimination System (NPDES). 2006. U.S. Environmental Protection Agency. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=69 Infiltration Basins. *Structural BMP Specifications for the Massachusetts Stormwater Handbook: Chapter 2*. Vol. 2. 86-93. http://www.mass.gov/dep/water/laws/v2c2.pdf Infiltration Systems: Infiltration Basins. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates*. 2001. Prepared by Barr Engineering Co. Prepared for the Metropolitan Council. http://www.metrocouncil.org/environment/Water/BMP/CH3_STInfilBasins.pdf TC-11 Infiltration Basin. *California Stormwater BMP Handbook: New Development and Redevelopment.* 2003. California Stormwater Quality Association. http://www.cabmphandbooks.com/documents/development/tc-11.pdf

BMP 6: Permeable Pavement Systems

Photo of permeable pavement. Source: Structural BMP Specifications for Massachusetts

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids		●	
Nitrogen		●	●
Phosphorous		●	
Metals			●
Bacteriological		●	
Hydrocarbons		●	●

Source: Iowa Stormwater Management Manual

Description: Permeable pavement systems (a.k.a. porous pavement, pervious pavement) are durable, load-bearing pervious pavement surfaces with underlying stone beds, which store rainwater before it infiltrates into the soil below. Permeable pavement systems reduce stormwater runoff and remove pollutants by replacing traditional impervious pavement, thereby, allowing rainfall to directly infiltrate through the permeable paver surface into the gravel base and eventually, to the underlying soil.

There are various types of permeable paving techniques, including porous asphalt, pervious concrete, and concrete grids. Porous asphalt and pervious concrete appear the same as traditional pavement, but are made permeable by manufacturing the mixtures with reduced amounts of fine materials and incorporated void spaces. Concrete grids are manufactured concrete units with incorporated permeable openings, which vary in size depending on the design. Modular grid designs are concrete units with regularly dispersed gaps that are filled with pervious materials such as sand, gravel, or grass. Monolithic grid designs, also known as permeable interlocking concrete pavement, are solid concrete units designed with small openings between their interlocking joints that are filled with highly permeable, small-sized aggregates. Innovative technology has also created permeable paving techniques that use alternative materials such as recycled high density polyethylene.

Although varying in design, all permeable pavement systems treat stormwater runoff through filtration and infiltration. Pervious pavements are highly effective at capturing runoff and removing both particulate and soluble pollutants. Sediment and other particulates are filtered and trapped above the permeable surface or within the aggregate chamber, then runoff is infiltrated into the subsoil where most of the remaining pollutants are removed through adsorption, straining, and microbial decomposition.

Feasibility: Permeable pavement systems are most suited for pedestrian-only areas, such as walkways and sidewalks, and low-volume, low-speed automobile areas, such as driveways, parking lots, road shoulders, and low-volume roadways. They can be designed to handle heavy loads, but are not recommended for high-volume, high-speed roadways because surface abrasion from constant traffic can cause the pervious pavement to deteriorate. In addition, they are not recommended for areas with high pollutant loads, high ground water tables, or proximate drinking supply wells due to water contamination concerns. Porous pavement can also have issues in cold climates because winter sanding may cause clogging.

BMP 6: Permeable Pavement Systems

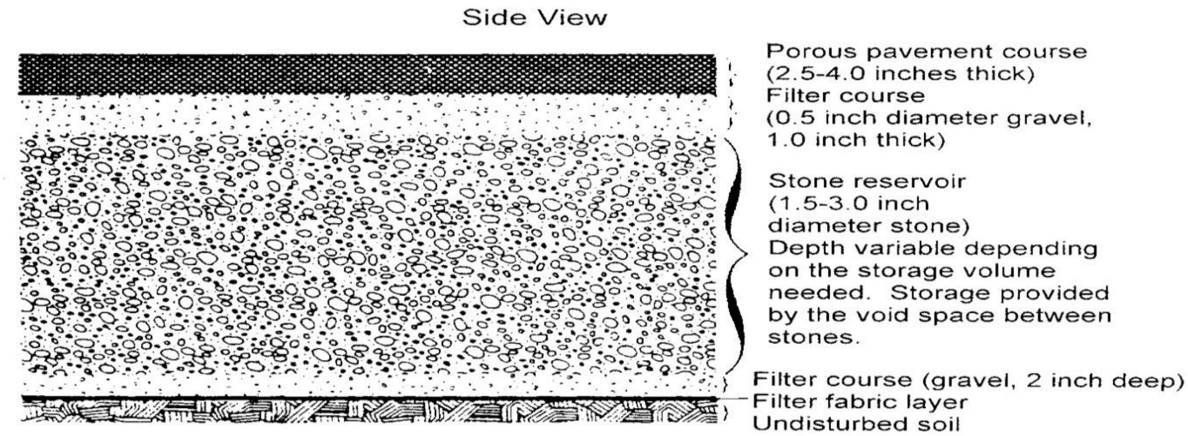

Figure 6: Schematic design of a porous pavement system. Source: Schueler, 1987

Feasibility continued: Soil type must be fairly permeable to allow for proper infiltration; therefore, pervious pavement is also not recommended in areas with low soil permeability. However, designs can be modified to include impermeable liners and underdrains that prevent soil infiltration and convey treated runoff elsewhere. Permeable paving is very useful in highly urbanized areas because it does not require extra permeable land and can be used as a retrofit for existing impervious surfaces.

Maintenance: Permeable pavement systems require extensive maintenance to properly function. Because the porous pavement, itself, pretreats runoff before it infiltrates to the layers below, aggressive maintenance is required to prevent clogging. Frequent jet washing and vacuum sweeping of porous asphalt and pervious concrete is necessary to maintain designed permeability. In addition, pervious materials should be replaced or reseeded as necessary for concrete grid systems. Permeable pavement systems should be inspected occasionally to make sure that they properly drain after storms and to look for any surface deterioration. It is recommended that signs be posted to identify porous pavement areas and that no winter sanding and minimal winter salting be applied over these permeable areas.

Advantages:

- Highly effective for pollutant removal
- Can reduce stormwater runoff volume and reduce peak discharge rates; thereby, preventing channel erosion and sediment loading into downstream receiving waters
- Can provide ground water recharge and help preserve baseflow of nearby streams
- Can be utilized in highly urbanized areas
- Suitable for cold climates if properly designed and maintained
- Can provide excellent public education opportunities

Limitations:

- Higher cost to install compared to conventional pavements
- Frequent and aggressive maintenance required to prevent clogging

BMP 6: Permeable Pavement Systems

Limitations continued:

- Winter sanding on pervious pavement not recommended due to potential clogging
- Winter salting or chemical deicing application should be minimal due to ground water contamination concerns
- Risk of ground water contamination depending on soil conditions and land use; not recommended for use in areas with highly contaminated runoff

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The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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BMP 7: Bioretention Systems

Photo of bioretention cell. Source: Structural BMP Specifications for Massachusetts

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen		●	
Phosphorous		●	●
Metals		●	●
Bacteriological		●	●
Hydrocarbons		●	

Source: Iowa Stormwater Management Manual

Description: Bioretention systems (a.k.a. rain gardens, bioretention cells, bioretention areas) are shallow, landscaped depressions that are designed to treat stormwater runoff by replicating the biological processes that occur in the soil of a forest or meadow. Bioretention areas use soils, plants, microbes, and a number of processes including adsorption and filtration to remove pollutants from stormwater.

Bioretention systems generally consist of a temporary ponding area, a layer of mulch, an engineered soil mix designed to have a desired permeability, and selected vegetation. Rainfall and runoff from adjacent impervious areas are diverted into the depression where water percolates through the bioretention cell and is either evapotranspirated by plants or infiltrated through the prepared soil mix into the subsoil, eventually migrating to ground water. Some bioretention cells will also include an impermeable liner and an underdrain that intercept and direct the filtered runoff back to the storm drain system. This method is recommended for areas where ground water contamination is likely, such as areas with shallow water tables or areas with high concentrations of pollutants in runoff. Bioretention areas should be designed to drain within at least 72 hours after a storm event and are not intended to have permanent pools of standing water.

Using the appropriate soil mix and planting the appropriate vegetation is critical for the effectiveness of bioretention systems. Prepared soil mix should be composed of mostly sandy or loamy soils that provide aeration and allow infiltration. Some clay may be necessary in the mix for adsorption of pollutants. Choosing a mixture of woody and herbaceous plant species with large root structures will also increase the effectiveness. Plants should be able to withstand dry spells between storms as well as brief periods of inundation with water. In arid climates, the use of native or xeriscape vegetation is recommended as these plants are often drought tolerant and resistant to local climate extremes. Invasive species should generally be avoided; however, some non-native, non-invasive species may serve as good additions.

Feasibility: Bioretention systems are widely applicable and useful in various commercial, residential, and industrial developments. They are well suited for highly urbanized areas and can be easily integrated into parking lots, median strips, and traffic islands. Bioretention areas are only useful for small drainage areas that are less than 5 acres. They are often found to enhance aesthetics and can increase property values. Bioretention cells can be used as stormwater retrofits and provide one of the few retrofit options available for highly urbanized areas. In addition, cell vegetation can easily be modified, making them suitable for a variety of climates and geologic conditions.

BMP 7: Bioretention Systems

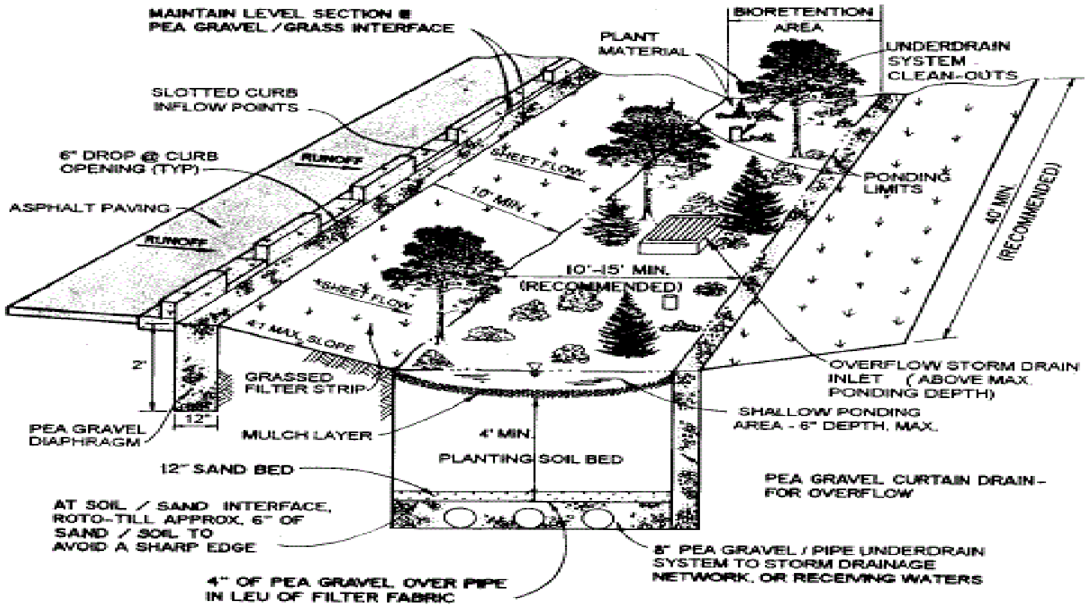

Figure 7. Schematic design of an enhanced bioretention system. Source: Iowa Stormwater Management Manual

Maintenance:

Bioretention areas initially require aggressive maintenance while plants are being established, but need less maintenance in the long term. When first placed into use, bioretention systems should be inspected on a monthly basis, but once determined that the system is functioning properly, inspections are only necessary twice a year. Soil and mulch should be inspected and replaced in exposed areas, diseased and dying plants should be treated or removed and replaced as needed, and litter and debris should be removed. Frequent watering and weeding may also be necessary initially so that the selected plants can successfully establish themselves. In addition, the entire bioretention cell should be re-mulched every 2 to 3 years.

Advantages:

- Highly effective for pollutant removal when properly designed and maintained
- Can be used on small lots or in highly urbanized areas with space restraints; one of the few viable options for stormwater retrofits in ultra-urban areas
- Can provide ground water recharge if designed to infiltrate water into subsoil
- Can create aesthetically pleasing amenities and increase property values
- Can provide habitat for wildlife, shade, windbreaks, and noise absorption
- Generally low maintenance required once vegetation is established; require less maintenance than lawns because do not need to be mowed, fertilized, or watered once established
- If implemented on a wide-scale, can reduce the volume of runoff from a drainage area and reduce flooding
- Do not cause warming of downstream waters and therefore, is a good option for areas with cold water streams

BMP 7: Bioretention Systems

Limitations:

- Cannot be used to treat a large drainage area
- Not recommended for areas with high sediment loads due to potential clogging
- Construction costs can be relatively high compared to other stormwater treatment practices
- Do not provide significant flood control, unless wide-scale utilization
- May reduce number of parking spots when incorporated into parking lot design

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BMP 8: Grassed Swales

Photo of a grassed channel. Source: Structural BMP Specifications for Massachusetts

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)
*Insufficient Data

	Low	Med	High
Suspended Solids		●	
Nitrogen	●	●	
Phosphorous	●	●	
Metals		●	●
Bacteriological	●		
Hydrocarbons	*	*	*

Source: Iowa Stormwater Management Manual

Description:

Grassed swales (a.k.a. grassed channels, dry swales, wet swales, biofilters, bioswales) are vegetated channels designed to treat and convey stormwater runoff at a slow, controlled rate. Pollutant and sediment removal in grassed channels is primarily accomplished by gravitational settling, filtration through the grass and soil, and infiltration through the subsoil. Grassed swales are often useful when utilized in a series of BMPs as a pretreatment mechanism.

Although vegetation within swales serves to reduce flow velocities, it is recommended that grassed swales should be constructed with a relatively wide, flat bottom to promote slow and even flow rates and to avoid channelization, erosion, and high velocities. Check dams, constructed perpendicular to the direction of flow, can be used within the swale to increase the detention time, allowing for more pollutant removal through settling, filtration, and infiltration.

Variations of the grassed swale include the dry swale and the wet swale. Dry swales differ from grassed swales because they include an underdrain system comprised of a perforated pipe surrounded by a gravel layer under the soil bed. The underdrain captures pretreated stormwater and conveys it back to storm drain system. In addition, when constructing dry swales, native soils are replaced with soil mixes that have desired permeability rates. Wet swales function similarly to stormwater wetlands by utilizing wetland vegetation to increase pollutant removal. They are designed to have shallow permanent pools of water at the bottom of the swale that support wetland vegetation. Similar to conventional grassed swales, wet swales do not have an underdrain system and are constructed with existing soils.

Feasibility:

Grassed swales are applicable in most regions, but may be limited in areas with arid or semi-arid climates, where irrigation needs may outweigh benefits, and in areas with cold climates, where ground freezing and the use of salts and de-icing chemicals may decrease effectiveness. However, although these conditions can limit this BMP, it can still be successfully implemented with careful design, maintenance, and examination of the available water resources. In addition, swales can provide a convenient area for snow storage. If used for this reason, salt-tolerant vegetation should be incorporated in the design and sediment build up from road-sanding will have to be routinely removed.

Because of their linear design, swales are often useful for treating and conveying runoff from roadways and highways. They can be used in place of curbs and gutters and are generally less expensive to install.

BMP 8: Grassed Swales

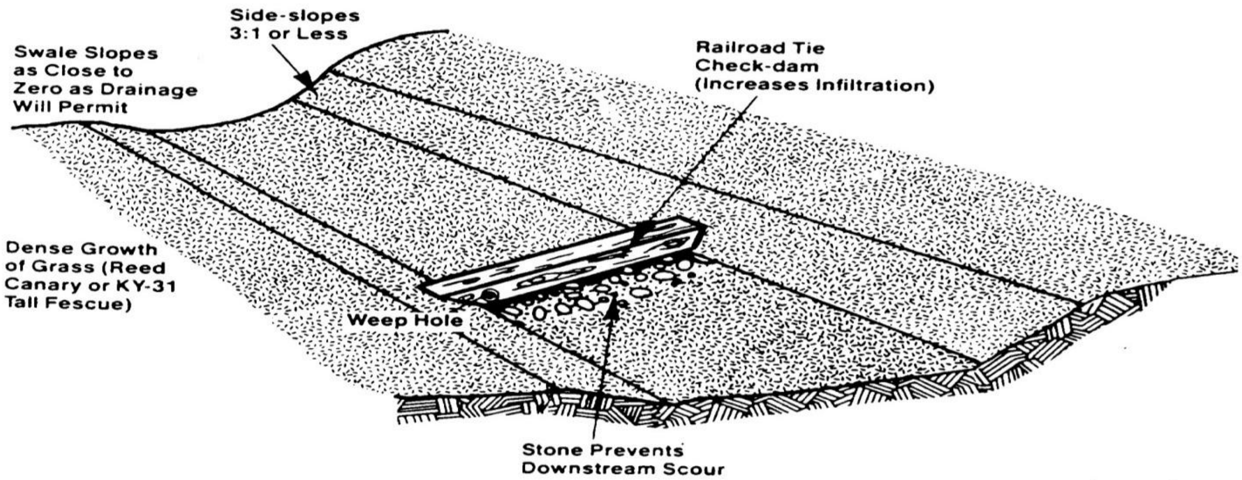

Figure 8: Schematic design of an enhanced grassed swale. Source: Schueler, 1987

Feasibility continued: Grassed swales are often used as stormwater retrofits for existing drainage ditches, and existing grassed swales can be retrofitted, themselves, by adding check dams to increase their effectiveness. Grassed channels, however, may not be well suited for highly urbanized areas, as their construction requires a relatively large pervious area. They are also not recommended in drainage areas with high sediment loads, due to potential clogging, or in areas with highly contaminated runoff, due to possible ground water contamination. The contributing drainage area for swales should be 5 acres or less.

Maintenance: Grassed swales can last an indefinite period of time if properly designed and maintained. The most frequent maintenance requirement is mowing. The grass turf should be mowed as needed to maintain a height of 3 to 4 inches. All the other maintenance activities are required semiannually the first year and only annually thereafter. These activities include removing trash and debris, inspecting for problems, such as clogging or erosion, and ensuring successful plant establishment. If the swale is not drawing down within 48 hours, soil tilling may be necessary. In addition, if the original grass cover is not successfully establishing itself, it may need to be replaced with an alternative grass species. For wet swales, failing wetland plants may also need replacement. Removal of sediment build up is also necessary when the accumulated sediment has reached 25 percent of the original design volume.

Advantages:

- Effective for removing sediment and other particulate pollutants
- Can reduce peak runoff volume and velocity
- Promotes infiltration and can provide ground water recharge
- Useful for treating runoff from highways and other roadways due to their linear structure; good retrofit option for existing drainage ditches
- Less expensive to build than traditional curb and gutter systems
- Good pretreatment option when used in conjunction with other BMPs
- Do not cause warming of downstream waters and therefore, are a good option for areas with cold water streams

BMP 8: Grassed Swales

Limitations:

- Individual swales can only treat runoff from a small drainage area of 5 acres or less
- Require higher maintenance than curb and gutter systems
- Use in highly developed areas is fairly limited due to space constraints
- Not recommended for use in drainage areas with high sediment loads or with high levels of contaminants due to potential clogging or potential ground water contamination
- If used in arid or cold climates, adjustments and increased maintenance must be made to ensure effectiveness
- Do not seem to be effective at removing bacteria
- Improperly designed or installed swales may not effectively remove pollutants
- Vegetation must be maintained for swales to properly function
- Concern for creating potential breeding habitat for mosquitos with wet swales

References:

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BMP 9: Vegetated Filter Strips

Photo of a vegetated filter strip. Source: California Stormwater BMP Handbook

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)
*Insufficient Data

	Low	Med	High
Suspended Solids			●
Nitrogen	●	●	
Phosphorous	●		
Metals			●
Bacteriological	*	*	*
Hydrocarbons	*	*	*

Source: Iowa Stormwater Management Manual

Description:

Vegetated filter strips (a.k.a. filter strips, grass buffer strips, grassed filters) are uniformly graded, densely vegetated sections of land that are designed to treat sheet flow runoff from adjacent land. Level spreaders can also be used to help distribute concentrated flows of runoff evenly across the filter strips. Vegetated filter strips are designed to slow runoff velocities, to trap sediments and other pollutants, and to promote infiltration into underlying soils. Filter strips can provide effective pollutant control, especially for particulate pollutants.

Although filter strips are often planted with turf grass, native vegetation can also be utilized, and their use can lead to more effective pollutant removal. In addition, trees and shrubs can be incorporated into filter strips to increase efficiency and create an aesthetic visual buffer. Filter strips differ from natural buffers in that they are constructed areas, designed specifically for the purpose of runoff control and pollutant removal. In addition, filter strips differ from grassed swales, in that swales are concave, channelized, vegetated systems, whereas filter strips are level-to-gently-sloped surfaces.

Filter strips were originally used as an agricultural treatment practice, but have become a common urban stormwater management practice. They are best suited to treating runoff from roadways, small parking lots, and roof downspouts. In addition, filter strips are often used in conjunction with other BMPs for runoff pretreatment.

Feasibility:

Filter strips are applicable in most regions, but are limited in arid or semi-arid climates, where the cost of irrigation may outweigh the water quality benefits. However, it can still be successfully implemented in these climates with careful design, maintenance, and examination of the available water resources. Properly designed vegetated filter strips generally require large amounts of pervious land. This size requirement makes them a poor option for highly urbanized areas and a poor option for stormwater retrofits.

Vegetated filter strips are not designed to handle concentrated, high velocity runoff flows well. High flow velocity from urban runoff can greatly reduce or completely hinder their effectiveness and may cause erosion and channelization. Therefore, it is recommended that urban filter strip designs incorporate a level spreader to distribute concentrated runoff along the width of the strip. In addition, due to concerns of ground water contamination, vegetated filter strips are not recommended in drainage areas with highly contaminated runoff. Filter strips should also be at least 2 feet away from the water table, to prevent ground water contamination, but no more than 4 feet away from the water table, to prevent filter strips from becoming waterlogged.

BMP 9: Vegetated Filter Strips

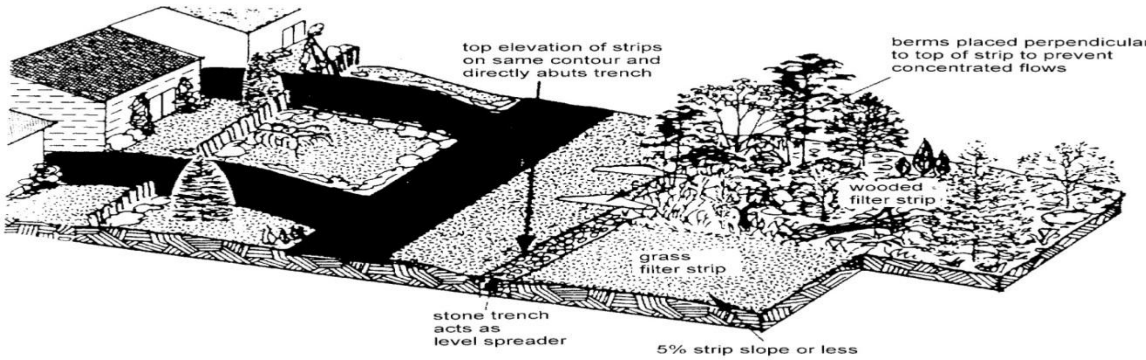

Figure 9: Schematic design of a filter strip. Source: Schueler, 1987

Feasibility continued: In cold climates, filter strips can also provide a convenient area for snow storage. If used for this reason, salt-tolerant vegetation should be incorporated in the design and sediment build up from road-sanding will have to be routinely removed. Contributing drainage areas for filter strips generally should be no greater than 5 acres. Vegetated filter strips also require proper slope gradations to function properly. Gradual slopes between 2 to 6 percent are most ideal for filter strips because anything less might encourage ponding and anything more might encourage concentrated flows.

Maintenance: Although maintenance for filter strips is somewhat infrequent, adequate maintenance is essential for them to remain effective. Filter strips should be routinely inspected, semiannually the first year and annually thereafter. Inspections should look for signs of erosion, for bare spots, and for other damage to the vegetation cover. Disturbed areas should be weeded, reseeded, and repaired as necessary. Sediment build up should also be removed from the bottom of the strip slope when it has accumulated to 25 percent of the original capacity. In addition, it is recommended that sediment be removed from the top of the strip to maintain sheet flow. If a level spreader is utilized, it should also be inspected and removed of sediment accumulation. If turf grass is utilized, the strip should be regularly mowed to maintain a grass height of approximately 2 to 4 inches.

Advantages:

- Effective for removing sediment and particulate pollutants
- Promotes infiltration and can provide ground water recharge
- Can be easily used in conjunction with other BMPs and serves as an effective pretreatment mechanism for stormwater runoff
- Often aesthetically pleasing and can provide open space for recreational activities
- Can be used as an “outer zone” of a stream buffer, thereby maintaining riparian zones along streams, reducing streambank erosion, and providing wildlife habitat
- Filter strips with taller, denser vegetation can provide visual barriers and can serve as windbreaks
- Relatively low cost to build and generally low-maintenance requirements
- Do not cause warming of downstream waters and therefore, are a good option for areas with cold water streams

BMP 9: Vegetated Filter Strips

Limitations:

- Not recommended for areas where sheet flow is difficult to maintain, such as hilly areas or highly impervious, urbanized areas
- Require a large area of pervious land to construct, thereby, restricting their use in highly urban areas and in areas where land is scarce or expensive and making them a poor option as a stormwater retrofit
- Do not provide enough storage to significantly reduce peak discharge or volume of runoff; therefore, recommended for use in conjunction with other BMPs
- Only effective if sheet flow can be maintained through the strip; concentrated, high velocity flows greatly reduce or completely hinder their effectiveness
- Slope gradations must be within set limits for filter strips to effectively function
- Pollutant removal efficiency data are less available; strips are difficult to monitor
- Concerns about ground water contamination limit their use in drainage areas with high pollutant loads

References:

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BMP 10: Sand and Organic Filters

Photo of sand filter system. Source: Iowa Stormwater Management Manual

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen	●		
Phosphorous		●	
Metals		●	
Bacteriological		●	
Hydrocarbons		●	

Source: Iowa Stormwater Management Manual

Description: Sand and organic filters (a.k.a. media filters, filter systems) are generally two-chambered filter systems consisting of a settling chamber and a filter bed that are housed in fixed beds or concrete vaults. In a media filter system, stormwater runoff is designed to first flow into the pretreatment chamber, which removes large sediments through physical settling. The runoff is then treated for finer particles and other pollutants by being strained through the filter bed, which is often filled with sand but can be filled with peat, other organic mediums, or a combination of these materials.

Typically, filter systems include an underdrain system designed to capture treated runoff and convey it to another treatment facility or to its ultimate point of discharge. An impermeable basin liner may also be necessary, if soil infiltration of treated runoff is not recommended due to ground water concerns, such as in areas with high concentrations of pollutants or areas with karst topography. Sand filters can also be built underground to accommodate areas with more challenging site specifications.

Sand filters have been shown to be effective in removing particulate pollutants and trace metals and moderately effective for nutrient and bacteria removal. In addition, the use of organic material filter beds or the use of a grass cover crop can improve the effectiveness of the system and increase pollutant removal. Filter systems are generally designed for stormwater runoff quality control, not quantity control.

Feasibility: Filter systems have few constraining factors and are applicable and adaptable to most regions of the country. Generally, media filters take up little space and therefore, can be used in highly developed sites. This small size advantage also makes them ideal to use as a stormwater retrofit for densely urbanized areas with space limitations. In addition, as long as an underdrain system and basin liner is utilized to redirect treated runoff and prevent soil infiltration, filter systems can be used in areas with poor infiltration rates, areas with high pollutant loads, or areas with course, overly-permeable soils. The contributing drainage area should be no more than 10 acres for surface media filters and should be no more than 2 acres for underground filters.

In cold climates, it is recommended to use underground sand filters with filter beds that are below the frost line, as surface filters may not be effective due to potential freezing. Peat and organic media are particularly ineffective in cold climate winters, as they are extremely susceptible to freezing solid. Larger settling chambers are also recommended to account for road sanding in cold climates. In addition, due to potential clogging, sand filters are not recommended for recently disturbed construction areas.

BMP 10: Sand and Organic Filters

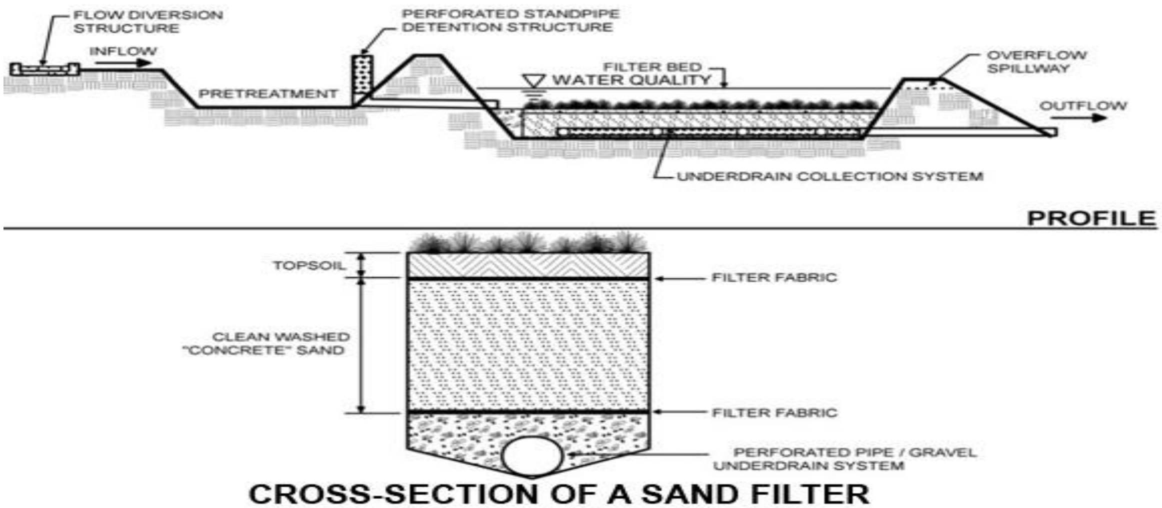

Figure 10: Profile and cross-section view of schematic design of filter system. Source: Structural BMP Specifications for Massachusetts

Maintenance: Filter systems require routine maintenance to ensure proper performance and prevent clogging. When first established, media filters should be inspected after every major storm event to ensure that the system is functioning properly. Thereafter, annual inspections are necessary to observe for sediment accumulation in both the settling chamber and the filter bed. Sediment build up in the settling chamber should be removed when the chamber is half full, removing only when the sediment is completely dry. Sediment removal from the filter beds is recommended when the accumulation exceeds 1 inch. In addition, trash and debris should be removed from the filter system every 6 months. It is recommended that sediment, trash, and debris be manually removed from the filter beds with rakes. Even with routine sediment removal, finer sediment that have penetrated deeper into the filtration media may eventually reduce the permeability rate of the filter bed to an unacceptable level, and some or all of the sand or other filter media will have to be replaced.

Advantages:

- Have very few site constraints and can be applied to most areas
- Can be used in highly urbanized, impervious areas with space limitations
- If designed with an underdrain system, can be used in watersheds with ground water contamination concerns, such as areas with high pollutant loads or areas with karst topography
- Effective for pollutant removal when properly designed and maintained
- Can provide ground water recharge if designed without an underdrain system
- Several modification options are available for design and filtration media type, making it adaptable to a site's space and pollutant removal needs
- Good retrofit capability
- Can be applied to small drainage areas of 2 to 10 acres

BMP 10: Sand and Organic Filters

Limitations:

- Pretreatment chamber is often required to prevent the filter media from clogging
- Require frequent and quite aggressive maintenance
- Can be relatively costly to build and install
- Do not provide significant quantity control; generally not designed to control peak discharges or to protect against downstream flooding
- Unless grass cover is incorporated into the design, surface filter systems can be very unattractive
- Not recommended for disturbed areas with heavy sediment loads, such as construction sites, due to likelihood of clogging
- Performance may be greatly reduced in winter seasons due to freezing

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The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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BMP 11: Green Roofs

Photo of a green roof. Source: Structural BMP Specifications for Massachusetts

Pollutant Removal

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Green roofs do seem to have the potential for pollutant removal through plant uptake and microbial soil process, but initial studies have found conflicting results in their removal efficiencies. While green roofs have been found to reduce the levels of nitrogen in stormwater runoff, studies have also shown them to increase the level of phosphorous in stormwater runoff. However, green roofs can capture a great amount of stormwater runoff from impervious roofs, thereby preventing it from flowing into storm drains and streams and transporting pollutants.

Description: Green roofs (a.k.a. vegetated roof covers, living roofs, eco-roofs) are permanent rooftop planting systems consisting of live vegetation planted in a lightweight constructed soil mix. Green roofs are designed to reduce stormwater runoff from commercial, industrial, and residential buildings by mimicking natural processes where plants and soils absorb and store rainwater until it is later transpired into the air. Vegetated roof covers can intercept anywhere from 40 to 100 percent of rooftop runoff, and rainfall that is not captured is cooled and slowed. Green roofs are especially effective for controlling intense, short-duration storms. Besides assisting with stormwater management, green roofs also can conserve energy by increasing thermal insulation, can reduce urban heat island effects, can improve air quality, can increase noise insulation, can create aesthetic value, can provide habitat for birds and other wildlife, and can increase a roof's durability and lifespan.

All green roofs are composed of various layers including but not limited to a water and root repellant layer, an optional insulation layer, a drainage system, a soil or substrate layer, and a plant layer (Figure 12). Green roofs are classified as either extensive or intensive, based on the thickness of the soil, the types of planted vegetation, and the intent of how the roof will be used. Extensive green roofs are generally lighter, utilizing a shallow soil or substrate layer (< 4 in) and employing native, low care vegetation, such as herbs, grasses, mosses, and drought-tolerant succulents. They require little maintenance and are primarily designed for flat or sloped, overburdened roofs that are not intended for human use. In contrast, intensive green roofs utilize a deeper soil or substrate layer (> 4 in) that can support a greater variety of plants including trees and shrubs. Intensive green roofs are often designed to be used by the public as park or relaxation areas. They require more intensive maintenance and greater initial capital and are generally only appropriate for flat roofs with higher structural load capacities.

Feasibility: Green roofs are applicable in all regions and can actually benefit buildings in extreme temperatures by providing additional insulation. Vegetated roof covers can be applied to new developments or retrofitted to existing buildings, provided that the roof of the building is structured such that it can support the weight of the green roof under fully saturated conditions. Green roofs are easily constructed on roofs with up to a 20 percent slope, but can even be utilized on roofs with up to a 40 percent slope if special design features are incorporated to prevent erosion and slumping and ensure plant survival. In general, plants and soil mix should always be carefully selected based on local climate, and often, drought-tolerant plants and irrigation systems are necessary to sustain vegetation. Green roofs are also ideal in highly urbanized areas where land is scarce.

BMP 11: Green Roofs

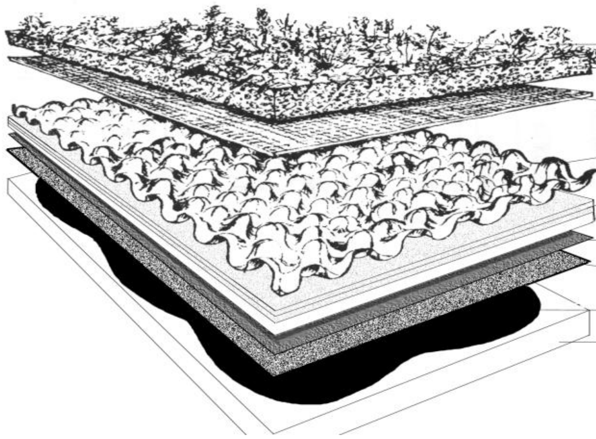

Figure 11: Diagram of the layers of a green roof. Source: Minnesota Urban Small Sites BMP Manual

Maintenance: Both extensive and intensive green roofs require routine maintenance, but vary with the frequency and types of maintenance. Immediately after installation, green roofs need to be regularly monitored to ensure that vegetation successfully establishes itself. Extensive green roofs may require periodic watering during dry seasons, especially in the initial establishment period; however, the use and establishment of drought-tolerant plant species will greatly reduce this requirement. Periodic fertilizing, weeding and mulching also may be needed initially, but should be less necessary as the plants establish themselves. Intensive green roofs require all the same maintenance activities and then some. They need to be maintained as any other landscaped area, which can involve trimming, pruning, gardening, and irrigation. If a leak should occur in the green roof, it is no more difficult to detect and fix than for a conventional roof.

Advantages:

- Reduces volume and peak rate of stormwater runoff; generally, extensive green roofs will absorb about 50 percent of rainfall
- Especially effective for controlling runoff from intense, short-duration storms
- Useful in highly impervious, urbanized areas or where land is scarce or expensive
- Are a good option for retrofitting existing impervious roofs; the construction of most preexisting flat-roofed buildings is already such that they can accommodate the weight of an extensive green roof without any structural modification
- Can reduce building costs for heating and cooling by providing thermal insulation
- Can increase the life expectancy of a rooftop by shielding the actual roof from intense temperatures and direct sunlight
- Can provide several other benefits, such as reducing the urban heat island effect, increasing sound insulation, increasing aesthetics, providing habitat, improving air quality, and creating a public amenity
- Water that does flow off roof is slowed and cooled, benefitting areas with cold water streams or fisheries
- Provide a good utilization of otherwise unused impervious space

BMP 11: Green Roofs

Limitations:

- Can be expensive to design and construct, especially if retrofitting an existing building that does not meet the structural capacity
- Maintenance for green roofs is generally higher than for conventional roofs
- Extreme sun and wind conditions may present a challenge for plant survival
- In most climates, green roofs require the use of drought-tolerant plants or irrigation systems to sustain vegetation
- The weight of snow, in addition to the green roof components, during winter months should also be factored in and may limit applications
- Damage to waterproofing materials may have serious consequences for a building
- Do not provide any ground water recharge

References:

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BMP 12: Native Landscaping

Photo of a home with native landscaping. Source: Iowa Stormwater Management Manual

Pollutant Removal

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Native landscaping has the potential for high pollutant removal efficiencies, as they work similar to single lot, bioretention cells. In addition, by replacing a traditional turf lawn with a natural landscape, one also can prevent pollution by reducing or eliminating the need for fertilizers, pesticides, or herbicides. However, because native landscaping is generally confined to drainage areas from individual lots, its pollutant removal efficiency greatly increases as the practice becomes more widespread.

Description: Native landscaping (a.k.a. sustainable landscaping, natural landscaping) manages stormwater through the establishment of carefully chosen, native, deep rooted plants that promote the capture and treatment of runoff. Natural landscapes reduce stormwater runoff volumes by retaining rainfall and returning water through infiltration or transpiration. Deep root systems create pathways for water infiltration, prevent erosion, and increase the porosity and water holding capability of the soils, allowing for more runoff storage. The rainfall that is not captured is slowed and cooled. Sustainable landscapes also remove pollutants through plant uptake, filtration, adsorption, and microbial decomposition. In addition, maintenance of conventional lawns and gardens require frequent use of fertilizers, pesticides, and herbicides, which can contaminate stormwater runoff and receiving streams and water bodies. Native plants, however, are often resistant to local climate extremes and to local pests and diseases. This tolerance greatly reduces the needs of fertilizers, pesticides, and herbicides, which, in turn, reduces the amount of contaminated runoff.

Native landscaping can also reduce or completely eliminate the necessity for the regular mowing and watering of lawns. By reducing these maintenance needs, air-polluting emissions from mowers and runoff from lawn watering are also reduced. In general, once established, sustainable landscapes require less maintenance than conventional landscapes. If properly designed and maintained, natural landscaping can also provide shade and windbreaks, improve aesthetics and property values, provide wildlife habitat, and increase sound insulation, along with improving soil and water quality. In addition, the increased community interest in native landscaping can be used as a motivator and a gateway to educate the public and spread awareness about stormwater runoff issues. A list of commercially available native plants of Wyoming is included in Appendix C.

Feasibility: Native landscaping is applicable in all regions, as long as the plants and design are properly chosen and tailored to the specific local conditions. They can be used in a variety of locations, including individual residential lots or commercial areas, and although individual lots may not be able to capture a great volume of stormwater runoff, the environmental benefits will increase as the use of native landscaping becomes more widespread throughout the community.

The application of sustainable landscaping may be limited in urbanized areas due to the limited amount of pervious space. However, native landscaping is a good alternative or retrofit option for existing conventional lawns and landscapes. The practice of using native vegetation is also recommended and often incorporated into other BMPs, such as bioretention systems, vegetated filter strips, vegetated swales, and green roofs.

BMP 12: Native Landscaping

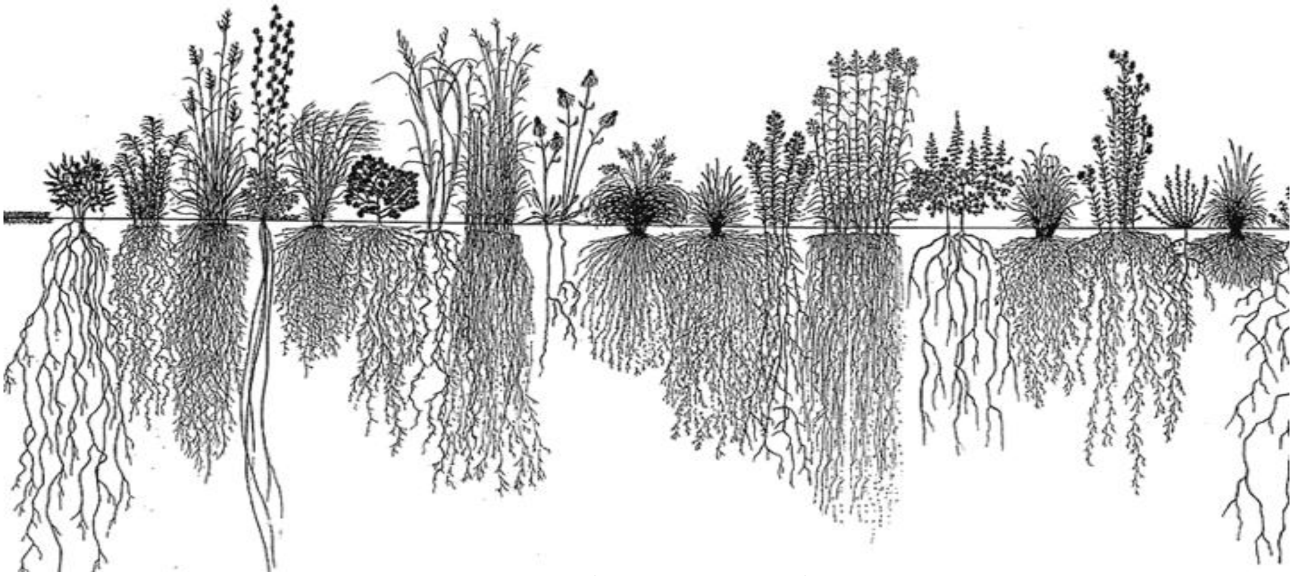

Figure 12: Diagram of the deep root systems of native plants. Source: Green Landscaping: Greenacres

Feasibility continued: Sustainable landscapes are most beneficial at controlling runoff and pollutants when they are used on a wide scale. However, the public's desire for manicured green turf grass lawns impedes this spread; therefore, local governments are encouraged to promote the use of natural landscaping and when possible, to retrofit areas around official buildings with native landscaping.

Maintenance: Although native landscaping require less maintenance than conventional grass lawns and non-native gardens, they do require routine landscaping maintenance needs such as weeding and watering, especially while the plants are first establishing themselves. The use of fertilizer is not generally recommended because it may cause excessive growth, but dead vegetation should be removed and replaced as necessary. Successful growth of native plants is essential for proper functioning of the natural landscape. Once the selected plants are successfully established, they require very little maintenance because they should be adapted to the local temperature, wind, and rainfall patterns.

Advantages:

- Provide a cost effective alternative to conventional turf grass lawns
- Require less time and money for ongoing maintenance than conventional landscapes
- Can reduce the rate and volume of stormwater runoff
- Remove sediment and pollutants from stormwater runoff to improve water quality
- Promotes infiltration and improves soil quality
- Can minimize and eliminate the need for the use of fertilizers, herbicides, and pesticides, thereby reducing the environmentally detrimental effects that these substances can cause
- Can minimize and eliminate the need for irrigation, thereby decreasing water demands and reducing the runoff produced from lawn irrigation

BMP 12: Native Landscaping

Advantages continued:

- Can increase aesthetics and property values
- Can improve air quality by removing carbon dioxide from the atmosphere and by minimizing the need to use lawn mowers, which produce air-polluting emissions
- Can provide several other benefits, such as increasing sound insulation, providing shade and windbreaks, cooling runoff, and providing wildlife habitat
- Encourages stormwater awareness, serves as a good educational tool for community-wide programs, and promotes positive behavioral changes
- Less costly to maintain, as an established native landscape requires less excess watering and chemical use, thereby eliminating the costs of these supplements

Limitations:

- Public's desire for green lawns limits the widespread use of native landscaping
- Establishment takes longer than turf grass
- Maintenance techniques for native landscapes not as widely known as for turf grass
- May create habitat for nuisance insects

References:

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BMP 13: Storm Drain Inlet Modifications

Photo of an infiltration trench. Source: California Stormwater BMP Handbook

Pollutant Removal
(Low = <30%; Medium = 30-65%; High = 65-100%)

	Low	Med	High
Suspended Solids			●
Nitrogen	●		
Phosphorous	●		
Metals		●	
Bacteriological	●		
Hydrocarbons		●	

Source: Iowa Stormwater Management Manual

Description: Storm drain inlets (a.k.a. catch basins, curb inlets) are inlets to storm drain systems that usually include an entrance grate and a sump to capture sediment, debris, and pollutants. The pollutant removal effectiveness of catch basins depends on their design and the amount of maintenance regularly performed to remove accumulated sediment from the sumps. Often, storm drain inlets best serve as stormwater pretreatment practices.

Storm drain inlets can be modified in different ways with various insert units. The basic catch basin insert generally includes a housing chamber or series of chambers that hold absorbent, filtration material that are designed to intercept and reduce stormwater pollutants. Filter mediums can be specifically chosen to address a site's pollutants of concern. Pollutants are generally removed through physical filtration or through absorption into the filter media.

Oil-water separators can also be used as catch basin inserts. These separators utilize the difference in density between oil and water to remove oil or other petroleum products from water. In addition, they can help remove sediment in runoff through gravitational settling. Generally, oil-water separator storm drain inserts consist of three chambers, and as water flows through these chambers, oils and grease separate by attaching to the settling sediment or by rising to the surface.

Other innovative manufactured products can be used as catch basin inserts, such as hydrodynamic separation systems or swirl separators. These systems contain internal components that create a swirling motion as stormwater flows through the cylindrical chamber. As the water moves through the swirling path, sediments settle out, and oils and grease are separated from the water and float to the surface.

Feasibility: Storm drain inlets can be adapted to all regions of the country and are ideal for highly urbanized areas where land availability is limited. They are restricted to small contributing drainage areas of 2 acres or less, but often these areas are mostly or entirely impervious. Catch basins inserts are generally not suited as stand-alone practices and are ideally used as pretreatment for other stormwater management practices.

Catch basin inserts can be used to retrofit existing storm drain inlets to improve their pollutant removal effectiveness and can be designed to target specific pollutants by adapting the type of insert unit or by modifying the filtration medium. A simple retrofit option for existing storm drain inlets is to add a grate to prevent trash and debris from entering the storm drain system.

BMP 13: Storm Drain Inlet Modifications

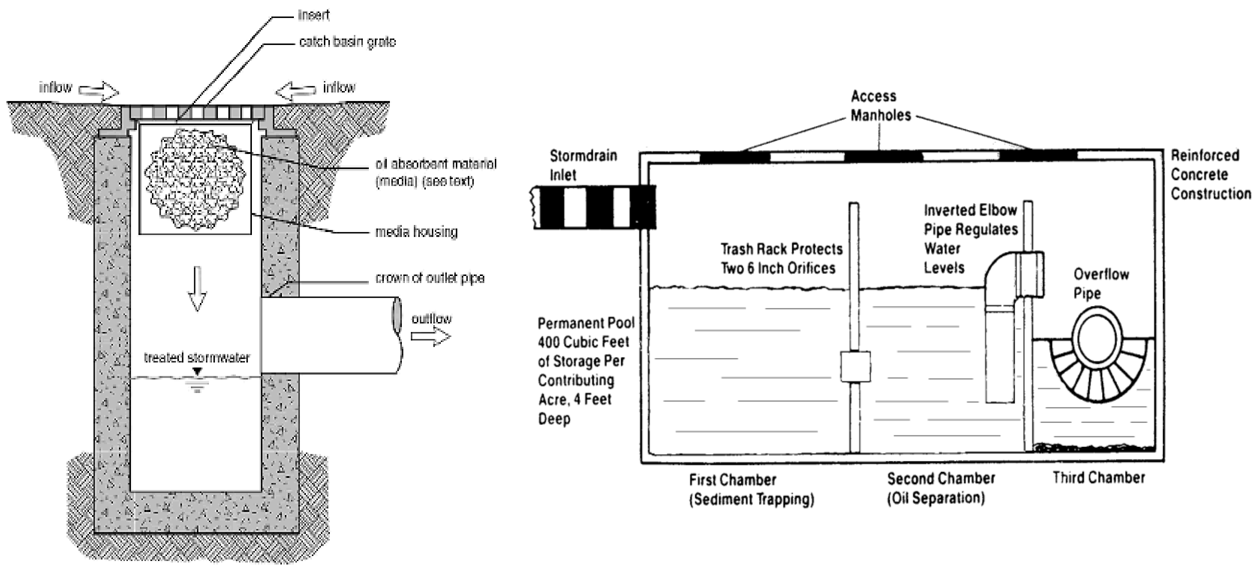

Figure 13: Schematic design of the sectional view of a catch basin insert and an oil-water separator insert. Source: NPDES and Schueler, 1987

Maintenance:

Storm drain inlets require frequent maintenance for proper functioning. Inlets require inspections and clean-outs to remove trash and debris, accumulated sediment, oils, and other pollutants. Typical maintenance of catch basins inserts includes the removal of trash and debris from grates and the removal of accumulated sediment using a vactor truck. At a minimum, basic catch basin inserts should be cleaned at least once or twice a year. However, increased frequency of maintenance has been shown to improve the performance of catch basins.

Hydrodynamic separator storm drain inserts require more frequent maintenance, especially after the first year of installation. Generally, separator inserts should be quarterly inspected and maintained, and sediment and pollutant removal should be performed with a vactor truck. Disposal of collected sediment from some inserts can be difficult due to hazardous waste, pretreatment, or ground water regulations. This is particularly true for accumulated sediment from storm drain inlets used in areas with high, concentrated pollutant loads.

Advantages:

- If properly designed, can reduce amount of sediments, oil and grease, and trash and debris carried by stormwater runoff
- Do not require much site space and can often be used in highly impervious, fully developed, urbanized areas
- Can be modified to target and reduce specific pollutants
- Can be used as pretreatment for other stormwater management practices
- Can be used in areas with high, concentrated pollutant loads
- Inserts can be used to retrofit existing storm drains and make them more effective at pollutant removal

BMP 13: Storm Drain Inlet Modifications

Limitations:

- Efficiency and pollutant removal rates can greatly vary; not recommended as a stand-alone stormwater management practice
- Various types of inserts have specific design and site constraints and use limitations
- Frequent maintenance is necessary for proper functioning; effectiveness can be greatly reduced if regular maintenance is not conducted
- Can be more costly than other treatment methods due to high capital and operation costs
- Subject to freezing in cold climates

References:

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2.3 Erosion and Sediment Control

Although some of the BMPs discussed previously help mitigate the effects of erosion and sediment deposition, some BMPs are established primarily to prevent erosion and sedimentation from occurring. In addition, although BMPs that temporarily treat stormwater runoff from construction activities are regulated under WYPDES, some of these temporary BMPs can overlap with more permanent practices that control erosion and sedimentation from conditions that encourage erosion on a perpetual basis such as wind or steep topography. Several regions within the state of Wyoming are susceptible to these types of conditions. Therefore, the Wyoming Nonpoint Source Program found it appropriate to cover wind and structural erosion control BMPs that can be used not only as temporary methods for construction sites, but also as permanent erosion control methods.

Several of these practices prevent erosion by creating permanent physical barriers or stabilizers. For example, vegetated windbreaks and fences create physical barriers to block the wind, thereby preventing wind erosion. Permanent slope diversions also use physical barriers to prevent erosion and sedimentation caused by stormwater runoff. These barriers are generally created with berms, ridges, or channels that are placed laterally along slopes to intercept and divert stormwater runoff. Some slope diversion structures use grassed channels that can also work to promote infiltration.

Seeding, sodding, and mulching also prevent both wind and structural erosion by stabilizing barren or exposed soil. These methods can also help promote infiltration and remove pollutants from runoff through plant uptake and other biological processes. Riprap or gravel can also be used as a means to help stabilize disturbed soils on slopes, near drainage inlets or outlets, or on dirt roads. Water sprinkling and adhesive spraying can also be used to stabilize loose soils, but are usually temporary solutions and can potentially have detrimental effects on the environment.

This section only touches briefly on various methods for erosion and sediment control. Other urban BMPs that function to provide erosion control will be evaluated on a case-by-case basis for funding by the Wyoming Nonpoint Source Program. For more information on the selected wind and structural erosion control methods, refer to the references section of the factsheets. In addition, for more information on other erosion and sediment control methods refer to the WYPDES Storm Water Program website or to the references listed under Section 1.8 of this document.

BMP 14: Wind Erosion Control

Photo of dust control truck utilizing water spraying. Source: IIHR

Pollutant Removal

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Wind erosion control methods work to reduce pollution by preventing sediment and its associated pollutants from reaching streams and other water bodies. Some methods, such as vegetation cover or vegetated windbreaks, can also improve water quality by slowing runoff, promoting infiltration and removing pollutants through plant uptake and other biological processes. In addition, wind erosion controls can improve air quality by controlling airborne soils and other particulates.

Description: Wind erosion control (a.k.a. dust control) methods use various techniques to limit the airborne movement of dust from disturbed surfaces and windy areas. Although dust control measures are mostly applied to recently disturbed construction areas, their application is also particularly important in wind prone areas. Control measures generally aim to prevent wind erosion by protecting soil surfaces, reducing wind velocities, or roughening surfaces.

Several different practices can be employed to prevent wind erosion, including but not limited to vegetating, mulching, matting, building physical barriers, water sprinkling, adhesive spraying, gravel lying, or surface roughening. Covering and stabilizing barren, exposed soil surfaces by seeding, sodding, mulching, or matting can greatly prevent airborne sedimentation along with slowing runoff and providing some pollutant removal capabilities. Surface roughening through tillage can also reduce wind erosion because once the surface is tilled, only the ridges are exposed to the wind.

For more frequented areas, water sprinkling or adhesive spraying may be appropriate for stabilizing exposed soils, but they are temporary in nature, require frequent recurring applications, and can potentially be harmful to the surrounding environment. Using stone or gravel to stabilize dirt roads can be a very effective option for dust control. In addition, windbreaks and barriers can help with dust control by obstructing and slowing the wind near the ground and preventing soil from blowing off site. Board fences, straw bales, or tree and shrub vegetation can all serve as wind barriers. In addition, vegetated windbreaks can help stabilize soils, slow stormwater runoff, promote infiltration, provide some pollutant removal capabilities, and enhance aesthetics.

Feasibility: Climate, traffic volume, soil type, adhesive properties, and frequency of application are all key factors in determining the best method to use for wind erosion control. Seeding and sodding can be appropriate for most areas that are not subject to traffic. In arid climates, graveling, mulching, or surface roughening may be more suitable, as irrigation costs may outweigh the benefits of seeding or sodding. Mulching, matting, and surface roughening, however, can also be limited by traffic volume. Methods such as watering or spray adhesives can be used in trafficked areas. However, water sprinkling may only be suitable for heavily visited areas, as it requires frequent applications, and chemical adhesives should only be used in areas where water contamination is not a concern.

Windbreaks and barriers have very few limitations and can be adapted in all areas. They are recommended in high wind areas where natural or manmade windbreaks do not already exist. When placed along roads, they can also reduce snow removal costs and enhance driver safety.

BMP 14: Wind Erosion Control

Maintenance:

All dust control methods require periodic maintenance, but the frequency varies depending on the technique utilized. Water sprinkling is the most maintenance heavy method, as it is typically only effective for 1 to 12 hours and therefore, requires frequent application. However, water additives, such as magnesium chloride, can be used to increase the efficiency of water sprinkling and decrease the frequency of applications. Spray-on adhesives generally require 1 to 2 treatments per season. In addition, vegetation, mulch, and gravel should be annually inspected and reseeded and replaced as necessary. When vegetation cover or vegetated windbreak control methods are utilized, weeding, mowing, and periodic pruning may also be necessary to ensure successful establishment of grasses, trees, and shrubs. Other barrier structures, such as fences, should also be annually inspected for damaged areas and repaired or replaced.

Advantages:

- Lowers the amount of sediment in runoff
- Can improve air quality by controlling airborne soil and other particulates
- Dust control methods are widely applicable
- Most methods are inexpensive and easy to install, apply, and maintain
- Seeds can be mixed with adhesive sprays to prevent seeds from being blown away
- Vegetation covers and windbreak methods help stabilize soils and can slow stormwater runoff and promote infiltration, thereby providing some stormwater management and water quality benefits

Limitations:

- Some temporary dust controls, such as water sprinkling, only prevent dust for a short period and must be frequently reapplied to be effective
- Watering or other liquid dust control measures may cause erosion and wash sediment or other particulates into the drainage systems
- Chemical spray-on adhesives can be expensive and can potentially cause both surface and ground water contamination
- Some spray-on adhesives can reduce infiltration rates and inhibit plant growth

References:

The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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BMP 15: Structural Erosion Control

Photo of riprap outlet protection. Source: IIHR

Pollutant Removal

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Similar to wind erosion control methods, structural erosion control methods, work to reduce pollution by preventing sediment and its associated pollutants from reaching streams and other water bodies. Using grassed channels to catch and divert runoff from slopes can also improve water quality by promoting infiltration and removing pollutants through plant uptake and other biological processes. In addition, slope diversions can promote vegetation growth on slopes, which will, in turn, prevent erosion and provide water quality benefits.

Description:

There are several structural erosion control methods that are used to provide permanent or temporary protection against erosion. In this section, we will focus on two structural methods that can be installed as permanent management practices: inlet and outlet riprap and permanent slope diversions.

Riprap is a permanent, erosion resistant layer of crushed stone or rock that is placed at or below storm drain inlets or outlets. Riprap inlet and outlet protection works to prevent erosion and scouring by reducing the speed of concentrated runoff at inlet and outlets. In addition, riprap protection can reduce the amount of downstream erosion. In general, riprap protection is an easily constructed, permanent method of protection that is sufficient for many situations.

Permanent slope diversions (a.k.a. diversion structures, earth dikes, waterbars) are typically channels or ridges that are constructed in a manner to intercept and divert runoff to a desired location. Diversion structures are generally placed laterally across a slope and are designed to prevent slope erosion by collecting the down-slope of runoff and redirecting the runoff to outlets that can convey the water without causing erosion. Steep slope diversion terraces break up a slope and keep water from proceeding down slope at increasing volume and velocity. Diversion structures can be used at the top of a slope to prevent down-slope runoff or at the middle or bottom of a slope to capture and divert excess slope runoff.

Slope diversions can be very effective for erosion control on steep or long slopes. In addition, their use can help promote the successful establishment of vegetation growing on slopes. Permanent slope diversions are often used on slopes near residential areas where uncontrolled slope runoff, erosion, and sedimentation might cause property damage. However, diversion structures can also be used as temporary erosion control measures to divert runoff until permanent management systems can be put in place or until vegetation is able to properly establish itself, and to divert runoff from construction sites or other highly disturbed sites.

Feasibility:

Riprap protection and diversion structures have few limitations and are applicable in all regions. It is not recommended to use riprap protection on steep slopes, as rocks can be unstable. However, wire mesh or chain link fences can be utilized to secure riprap installations on steep slopes or in high flow areas. Size and shape of rocks can be properly selected based on the stress of the flow and on the slope that they will be subjected to. In general, a well-graded mixture of rock sizes should be utilized, but on steeper slopes or areas with high flows, larger more angled rocks are recommended.

BMP 15: Structural Erosion Control

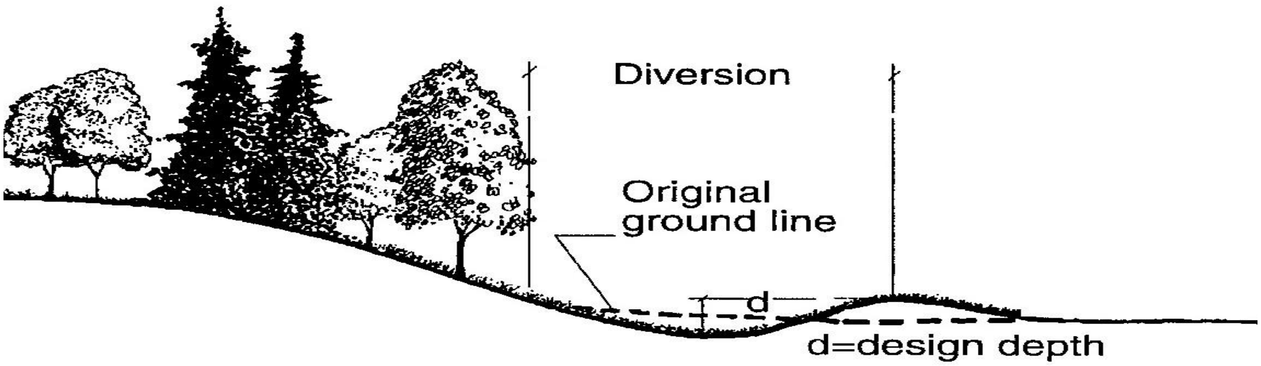

Figure 14: Schematic design of a permanent slope diversion structure. Source: Minnesota Urban Small Sites BMP Manual

Feasibility continued: Diversion structures can be easily modified to be appropriate for any region. They can be constructed with vegetated swales as channels, which would additionally promote infiltration along with collecting and conveying slope runoff. However, channels do not have to be vegetated and can be constructed with rock or concrete. Hardened channels may be more appropriate in arid climates where vegetated swales may be infeasible due to irrigation needs.

Maintenance: Inlet and outlet riprap requires low maintenance. Riprap should be inspected for damage annually and after major storms. Damaged areas should be repaired, and additional riprap may need to be added to prevent progressive failure. Weed and brush growth may also need to be controlled in some areas.

Diversion structures require frequent inspection and maintenance. Temporary slope diversions used in construction areas are especially maintenance heavy and need weekly inspections and sediment removal. Permanent slope diversions require frequent bimonthly inspections when first being established, but the demand decreases once stabilized. Established slope diversions should still be inspected regularly and cleared of sediment, repaired, and reseeded as necessary.

Advantages:

- Structural erosion control methods can be widely used and have few site restrictions
- Both methods can be easily constructed and can be used as permanent methods for erosion and sedimentation control
- Riprap can be very durable and riprap outlet protection can be very effective at reducing scour and downstream erosion if properly designed and installed
- Materials for riprap inlet and outlet protection are readily available in most areas
- Permanent slope diversions can prevent property damage and value loss
- Diversion structures can break up the concentration of water on long or steep slopes and can help contain and prevent sedimentation from highly disturbed areas
- By redirecting runoff, diversion structures can be used to promote the growth and establishment of vegetation on erosion prone slopes

BMP 15: Structural Erosion Control

Limitations:

- If installed and used improperly, riprap can actually increase erosion
- Riprap can be more expensive than other stabilization options
- Rock inlet and outlet protection is generally not found to be aesthetically pleasing
- Diversion structures require frequent maintenance; must be stabilized immediately after construction so that the channel or ridge itself is not subject to erosion
- High velocity flows can cause erosion in the diversion structure

References:

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2.4 Public Education, Rain Barrels and Cisterns, Preventative Practices, and Low Impact Development

Educating the public about nonpoint source pollution is an essential BMP to improve urban stormwater quality. Education, outreach, and public involvement are critical in any stormwater management program, as a significant amount of urban nonpoint source pollution is a result of cumulative actions by the public. Often urban residents are not aware that storm sewers actually convey runoff directly to nearby water bodies without treatment. Residents should also understand that while the actions of a single person may seem insignificant, when combined with similar actions of hundreds or thousands of other residents, the potential to pollute their local waters is very real. For example, the quart of oil dumped down a storm drain by one person on any given Saturday may be repeated hundreds of times that day. By educating the public about stormwater pollution and the common activities of residents that can generate pollution, the amount of polluted urban runoff can be greatly reduced.

The United States Environmental Protection Agency (EPA) provides a wealth of information about public education and outreach as well as tools for obtaining public involvement in stormwater management planning. This information is available on the EPA National Menu of Stormwater Best Management Practices website, along with the EPA Urban Waters website. More sources and information about public education as a best management practice can be found under the BMP 16: Education factsheet. In addition, a list of stormwater pollution prevention tips for homeowners can be found in Appendix **D**.

The installation and use of rain barrels or cisterns is one pollution prevention practice that is commonly favored by the public. In terms of overall urban runoff reduction, rain barrels and cisterns can be limited since only a minimal amount of runoff from impervious surfaces is detained; however, the great amount of community interest in rain barrel programs makes them notable in this manual. The increased interest in rain barrel and cistern programs can be used as a motivator and a gateway to promote public education and to help spread awareness about urban nonpoint source pollution and stormwater runoff. Rain barrel programs can, in turn, inform and encourage the public to adopt other behaviors and implement other practices that can reduce stormwater runoff pollution.

There are several other management methods that can improve water quality by preventing pollution. Most of these precautionary measures prevent pollution from reaching runoff in the first place. These preventative practices can be as simple as litter removal or proper waste disposal. These simple methods, however, can be very effective at reducing the amount of pollution in stormwater runoff. One preventative measure works to prevent the contamination of natural water bodies by directing untreated runoff away from natural channels, and another method works by preventing the destruction of natural vegetation areas, which promote natural treatment of stormwater runoff through plant uptake and infiltration. The Wyoming Nonpoint Source Program recognizes the importance of these different preventative measures and briefly describes some of the various preventative practices for urban areas under BMP 18.

Septic system maintenance applies to urban and rural area residents who manage wastewater through an on-site septic system rather than a centralized wastewater management facility. While septic systems can be effective, proper installation, operation, and maintenance are critical to managing wastewater and preventing contamination of ground water and/or surface water with pathogens and other pollutants. Ensuring proper maintenance of working systems and replacing failed systems helps to protect and restore water quality (see BMP 19)

Low impact development (LID) is a practice that combines several other urban BMPs to develop an encompassing approach to controlling stormwater pollution in urban communities. LID emphasizes cost-effective, on-site strategies that replicate predevelopment hydrology and reduce the impacts of new development. LID designs often utilize BMPs that can be easily integrated into urban areas and that can prevent stormwater runoff by capturing and infiltrating rainfall and snowmelt at the source. Some of these practices, such as bioretention systems, grass swales, green roofs, and permeable pavement systems, have been previously discussed in this manual. LID also utilizes planning and design to find ways to construct new development in a sustainable manner. LID practices provide several environmental and economic benefits. The practice of low impact development is further described under BMP 20.

BMP 16: Education

Photo of a storm drain stencil and a "No dumping. Drains to river" sticker. Source: City of Billings

Pollutant Removal

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Public education can prevent runoff contamination by reducing or eliminating pollutants at their source. The amount of pollutants introduced into the water system can be greatly reduced by educating the public about the effects of stormwater pollution and the common activities can generate these pollutants. This information may encourage or inspire individuals to change behaviors and limit their pollution generating activities.

Description:

Although education differs from other BMPs in that it is a broad, non-structural subject that encompasses several means of implementation, educating the public about nonpoint source pollution is an essential urban best management practice. Much of urban nonpoint source pollution is the result of cumulative actions by many individuals, businesses, and industries. In turn, the reduction of polluted urban runoff relies upon the choices and actions of individuals, businesses, and industries. Often individuals and business owners are not aware that storm drains deliver runoff to nearby water bodies without treatment. Nor are they aware that some of their common practices, such as over-fertilization or improper material storage and disposal, may contribute to stormwater pollution. By educating the public about stormwater pollution and the common activities that can generate pollution, the amount of polluted urban runoff can potentially be greatly reduced.

Municipalities, businesses, and homeowners are key factors of stormwater management in urban areas, and public awareness programs must be tailored to meet the individual needs and interests of each segment of the community. For example, programs for municipalities might focus on providing public educational materials and developing outreach strategies. Business and industry programs might focus on company waste reduction, chemical reuse, and other pollution prevention techniques that can reduce or eliminate contaminants along with helping lower business costs and improving overall efficiency. Programs for homeowners might focus on the proper use and disposal of lawn fertilizers, herbicides, pesticides, and common household hazardous materials, such as used oil, paints, solvents and cleaners. The EPA divides public education on urban stormwater runoff into five major categories – Developing Municipal Outreach Programs, Promoting the Stormwater Message, Stormwater Outreach Materials, Education for Homeowners, and Education for Businesses. Under each section are factsheets for various detailed BMP methods designed for the specified category (see References this section: Public Education and Outreach on Stormwater Impacts).

Generally, education programs should provide concrete information about stormwater pollutant sources and causes, along with specific information about proper storage, use, and disposal of materials which may cause pollution. It is also recommended to get community groups involved. School or youth groups may be interested in stenciling storm drains with a message such as, "Dump No Waste; Drains to River". In addition, pre-established "Adopt-a-River" or other environmental programs can be adapted to include educational efforts on the effects of pollution in stormwater runoff. Educational materials or presentations can also be made available at a variety of community forums such as town meetings, service organizations, Earth Day events, local fairs, and festivals.

BMP 16: Education

Description continued:

Information on stormwater BMPs and educational materials are available from many sources. Federal, state, and local governments can often provide written material and information on improving water quality. For example, along with the previously mentioned public education BMP factsheets, EPA has a webpage dedicated to providing educational materials and brochures on stormwater runoff (see References this section: EPA Stormwater Outreach Materials and Reference Documents). The EPA Nonpoint Source Outreach Toolbox also offers a variety of educational and promotional material. A list of some household stormwater pollution prevention practices is also provided in Appendix D. Several other organizations are involved in improving urban water quality and public education; references to some of these groups are included below. Public education is one of the most effective ways of preventing stormwater pollution. Building awareness about the problems and solutions to urban nonpoint source pollution is critical to developing public support for efforts to control pollution. Community understanding, support, and participation, not only can encourage the public to adopt individual behaviors that would reduce pollution from stormwater runoff, but it can also make widespread stormwater programs and ordinances more effective.

References:

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BMP 17: Rain Barrels and Cisterns

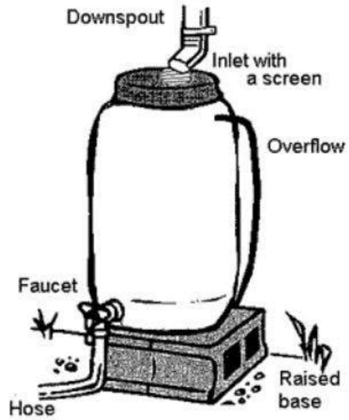

Photo and diagram of a rain barrel. Source: Structural BMP Specifications for Massachusetts

Pollutant Removal
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Although rain barrels and cisterns offer no direct pollutant removal benefit, rooftops do contribute to the overall impervious cover in urban settings. Runoff from impervious areas generally flows into storm drains and eventually streams and often transports pollutants. However, by capturing rooftop runoff, the amount of urban stormwater runoff is reduced.

Description: Rain barrels and cisterns are the simplest on-lot treatment systems. They work by collecting and storing rainwater from rooftops. Diverting rainwater into rain barrels or cisterns reduces contributions to stormwater runoff from impervious cover. In addition, collected rooftop runoff generally has low pollutant content, and therefore, can be reused for landscaping and other non-potable uses without treatment.

Rain barrels and cisterns differ from one another mostly with size. A rain barrel is usually designed for a down spout of a single home and is composed of a 55 gallon drum that fits under the gutter down spout, a screen grate that keeps debris and insects out, and a hose attached to the bottom of the barrel that allows the homeowner to easily use stored water. Water is distributed out from the rain barrel by gravity pressure.

A cistern is a larger system that consists of a partially or fully buried tank with a secure cover and an electrical discharge pump. Cisterns capture and store more water than rain barrels and can be used to collect water from multiple down spouts and even multiple roofs. The water can then be distributed where needed via the electrical pump.

In terms of large urban runoff reduction, the overall effectiveness of rain barrels may be limited since the amount of water captured is minimal compared to the runoff from other impervious surfaces in urban areas. However, there has been much community interest in rain barrel programs, and this interest can be used as a motivator and a gateway to educate the public and spread awareness about stormwater runoff issues. The Wyoming Nonpoint Source Program recommends that rain barrel and cistern programs strive to inform and encourage homeowners to adopt other behaviors that would reduce pollution from stormwater runoff, such as using less fertilizer or building rain gardens.

Feasibility: Rain barrels and cisterns have very few site constraints and can be applied in a wide variety of site conditions. Homeowners should have a use for the water collected in order for the practice to be effective. In addition, designs should accommodate overflow and freezing conditions.

Rain barrels, in particular, are relatively inexpensive and easy to install, operate, and maintain. They are particularly beneficial for regions with arid to semi-arid climates, where water conservation is an issue.

BMP 17: Rain Barrels and Cisterns

Maintenance: Rain barrels and cisterns require minimal maintenance needs. The unit and its components should be inspected semiannually, replacing or repairing any worn out parts when necessary. Preventative measures, such as larvicide or mosquito-proof screens, should be used to prevent mosquito breeding, tanks should be cleaned out about once a year, and the system should be disconnected and drained prior to winter to prevent freezing and cracking. In addition, homeowners should use the water somewhat frequently to prevent overflow and therefore, increase effectiveness of the system.

Advantages:

- Simple and relatively inexpensive to install and maintain, with very few site constraints
- Reduce stormwater runoff from individual properties
- Can reduce water demand from public water systems and save property owners money on water bills; especially beneficial for those in semi-arid to arid climates, where water restrictions may limit use
- Encourage stormwater awareness, serve as good educational tools for community-wide programs, and promote positive behavioral changes

Limitations:

- Overall effectiveness is limited; only treats a relatively small portion of watershed from impervious cover
- If not properly sealed, may create mosquito breeding habitat
- Usefulness is dependent on homeowner using up the water between storm events; may be difficult to find uses for stored water since water is not potable
- Stored water not recommended for use on vegetable gardens due to the potential contaminants from the rooftop, such as bacteria from bird droppings
- Practice requires homeowners to perform some basic maintenance

References: The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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BMP 18: Preventative Practices

Photo of a 'pick up after you pet', litter prevention sign. Source: NPDES

Pollutant Removal

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Preventative practices work to reduce stormwater pollution by reducing or eliminating pollution at its source. By taking precautionary and preventative measures, runoff contamination can be eliminated or greatly reduced. Pollution prevention practices can involve municipalities, industries, businesses, and homeowners. Practices can range from simple public tasks, such as picking up pet waste, to more complex municipal tasks, such as proper snow removal and storage.

Description:

As mentioned previously, preventative practices generally work to reduce contaminated stormwater runoff by preventing pollution from reaching the runoff itself or by preventing untreated runoff from reaching natural water bodies. Others also work by preventing the destruction or removal of naturally vegetated areas that can treat runoff through plant uptake, infiltration, and other biological processes. Different preventative practices will be briefly described in this factsheet.

Direct Runoff Away From Natural Channels:

Runoff that directly enters a natural waterway or is directly channeled to a natural water body may contain untreated pollutants. Urban runoff typically contains such road pollutants as hydrocarbons, metals, pesticides, fertilizers and sediments, and while natural water bodies can provide some stormwater treatment, it is EPA policy that they shall not be used as stormwater treatment options to avoid potential degradation of the functioning natural systems.

Control of nonpoint sources can reduce the need for other management actions. One way to prevent untreated runoff from reaching natural waters is to locate material stockpiles, access roads, and other land disturbing activities away from critical areas, such as steep slopes and highly erodible soils that drain into sensitive water bodies.

Contaminated runoff can also be prevented from entering the waterways by directing it into management areas or sanitary sewers that are designed to remove sediment and other pollutants before discharge into surface waters. Roof drains can also be directed to vegetated areas rather than storm sewers or captured with rain barrels or cisterns. In addition, since curb and gutter systems function as direct channels to surface waters, the elimination of curbs and gutters has been shown to reduce the amount of pollution entering streams and lakes. Without curbs or gutters, runoff can spread over vegetated areas where runoff velocities can be reduced and pollutants can be filtered out by plants or soils. In low-density developments, curb and gutter systems can be replaced by grassed swales to convey stormwater and further promote pollutant removal and infiltration. More information and references on grassed swales can be found under the BMP 8: Grassed Swales factsheet.

Leaking or failing connections to storm sewer systems, sanitary lines, or septic systems can also introduce a significant pollutant load to the environment. A program to locate and correct these faulty, contaminated, non-stormwater flows can also significantly reduce the amount of pollutants introduced to surface waters.

BMP 18: Preventative Practices

Description continued:

Proper Disposal of Accumulated Sediment:

When the accumulated sediment that is removed from stormwater treatment practices is disposed of in areas lacking sediment controls, these sediments can become resuspended by stormwater runoff or wind erosion. Proper disposal practices can prevent the resuspension of these sediments. Some recommended disposal methods are to place sediment spoils upstream of sediment traps and to not use sediment spoils as fill within the 100 year floodplain. In addition, seeding, sodding, mulching, or other erosion control methods can be utilized in sediment disposal areas. More information on some of these erosion control methods are discussed under the BMP 14: Wind Erosion Control factsheet.

Proper Snow Removal and Storage:

Due to the associated salts, chemicals, and roadway pollutants found in the snow accumulated from roadways, improper roadside snow removal can lead to damaged roadside vegetation, increased chloride levels in surface and ground waters, and increased stratification of lakes and ponds. Proper snow removal and storage practices are greatly recommended to protect water quality. Snow storage areas should be placed in areas where seepage and runoff cannot go directly into surface or ground waters. It is recommended that snow melt water be treated for pollutants by some best management practice before entering water bodies.

Snow removal management can also include proper use and storage of roadway salts. Salt use management methods, such as assuring proper application rates or using alternatives, can have economic, as well as environmental benefits. For example, sand is an alternative that can be less expensive and less harmful to vegetation and aquatic life. However, the use of sand should also be carefully evaluated and managed, as excess sand application can also pollute urban runoff and adversely affect nearby surface waters. In addition, the proper storage of road salts in covered areas with impermeable surfaces can reduce the negative environmental impacts.

Exposure Reduction:

Runoff that directly contacts stored toxic materials can transport pollutants to surface or ground water. Industries, municipalities, and homeowners can reduce pollution by reducing or eliminating the exposure of these materials. Pollution can be prevented by simply moving materials, products, or devices indoors, or by reducing the amount of outdoor manufacturing activities that may contribute pollution to runoff.

It is recommended that municipal, commercial, and industrial sites run an inventory on items that are exposed to rain. Raw material stockpiles, stored finished products, and machinery or engines which might leak fuel or oil are some examples of items that should be inventoried. The partial or total covering of stockpiled or stored material, loading and unloading areas, processing operations, or waste storage areas can reduce potential pollutants in runoff. In addition, inventory can be managed in such a way that the amount of raw materials and products on hand is kept to a minimum, which reduces wastes, storage costs, and the amount of potential pollutants exposed to stormwater.

General ‘good housekeeping’ by municipalities or industries can also prevent pollution. Good housekeeping involves activities such as maintaining equipment to be free of leaks, removing empty materials containers, or disposing of unused equipment. All of these activities reduce the amount of exposed pollutants.

BMP 18: Preventative Practices

Description continued:

Waste Management:

Improper waste management can increase pollutant loadings in runoff and often occur due to public unawareness of the proper disposal methods or due to the lack of disposal alternatives. Education on proper handling and disposal methods of wastes can prevent and reduce the amount of pollution.

Composting yard wastes is one pollution prevention waste management activity that homeowners and municipalities can take a part in. Composting reduces landfill volumes and can create natural fertile, nutrient-rich soils that's use can reduce the need for chemical fertilizer. Yard waste, such as leaves and grass clippings, can be composted, and many municipalities and counties offer residential yard waste pickups and composting facilities at little or no charge.

Municipalities that develop convenient, low-cost household hazardous waste collection programs can encourage homeowners and small businesses to properly dispose of their hazardous wastes. Products typically collected by these programs are used oil and antifreeze, unwanted paint, and unneeded household chemicals, such as cleaners, solvents, fertilizers, pesticides, and herbicides. Contact your local municipal government to see if hazardous waste collection programs are available in your area.

Business and industry programs can also implement pollution prevention techniques as a means of waste reduction. In addition, pollution prevention strategies can reduce business costs and improve overall manufacturing efficiency, while reducing the amount of pollutants introduced into the environment. Pollution prevention options include activities such as recycling or reusing materials to reduce the creation of waste or implementing strategies that reduce the use of hazardous materials.

Training and prevention programs can also teach employees about ways to reduce waste, proper waste management techniques, and other beneficial pollution prevention tips. Information on regional pollution prevention programs, training, or other activities can be found through the Pollution Prevention Resource Exchange (P2RX) website.

Litter Removal:

Litter can enter surface waters via wind and storm runoff events. Litter and yard wastes can clog stormwater control and conveyance structures, making the devices ineffective in stormwater pollutant control. In addition, contaminants such as plastics and styrofoam degrade slowly, while presenting environmental risks to fish and wildlife. Pet waste can also introduce fecal coliform bacteria to surface waters, which are a potential human health hazard for drinking and recreational water supplies.

The amount of litter can be reduced by promoting litter removal programs, such as Adopt-a-Highway, and local clean-up days within the community. Municipalities can also provide trash bins at frequented street intersections for people in vehicles or at public recreational areas. Residents should also be encouraged to "scoop the poop" when they walk their pets. Pet waste bags for dog walkers can be provided in parks or other commonly frequented residential areas. In addition, if animals, such as horses or cows, are being kept on small acreage properties close to urban areas, they should be watered away from streams, ponds, or lakes to prevent any direct entry of fecal material. Regular maintenance and trash and debris removal from stormwater BMP systems can also prevent clogging and ensure proper function of the systems.

BMP 18: Preventative Practices

Description continued:

Fertilizer, Herbicide, and Pesticide Management:

Frequent or excessive applications of fertilizers, herbicides, or pesticides can result in pollutant contamination in surface and ground waters. Discharges of these chemicals to surface or ground waters typically occur due to over application, improper application, or application during dormancy.

If fertilizers, herbicides, or pesticides are applied, application should be managed to achieve the greatest impact on target species. In some cases, spot verses blanket pesticide application is just as effective and uses significantly smaller amounts of pesticide. Reduced application rates not only decrease the amount of chemical introduced to the environment, but may also lower the amount spent on chemical control by businesses, homeowners, construction sites, and golf courses. In addition, the potential for off-site movement of chemicals can be reduced by selecting less toxic and more persistent chemicals, by applying chemicals more selectively, and by leaving a buffer area between the use site and surface waters.

Native landscaping can also greatly reduce or eliminate the necessity for lawn chemical use and can actually serve to treat stormwater runoff and promote infiltration. In general, native landscaping and xeriscaping can have several environmental benefits, can reduce overall lawn maintenance needs, and is a great alternative for traditional turf lawns. More information on natural landscaping can be found under the BMP 12: Native Landscaping factsheet.

Protect Natural and Riparian Vegetation:

Native vegetation and riparian habitats naturally stabilize stream banks and control sedimentation. Therefore, the removal of natural vegetation destabilizes soils and can result in increased soil loss and sediment loadings in surface waters. Further, in most instances, native vegetation provides better ground cover and stormwater treatment than developed plant communities, and removal of riparian habitat and predevelopment flora can result in decreased water quality. In addition, removing riparian vegetation can result in increased bank cutting, increased streambed scouring, increased water temperatures, decreased dissolved oxygen levels, and changes to natural flows.

Identifying, protecting, and preserving natural riparian buffers and systems can maintain an area’s environmental integrity. However, if vegetation must be removed, removal should be minimized. In construction areas, only sections essential for completing site construction should be cleared using minimum disturbance practices, and areas should be replanted with native species when possible. Natural vegetation can be protected from disturbance with fences, tree armoring, or retaining walls. Avoid disturbing vegetation on steep slopes or in other critical areas. Riparian buffers or streambank setbacks may also need to be established in areas where surface water quality is dependent upon riparian areas to maintain biological integrity.

BMP 19: Septic Systems

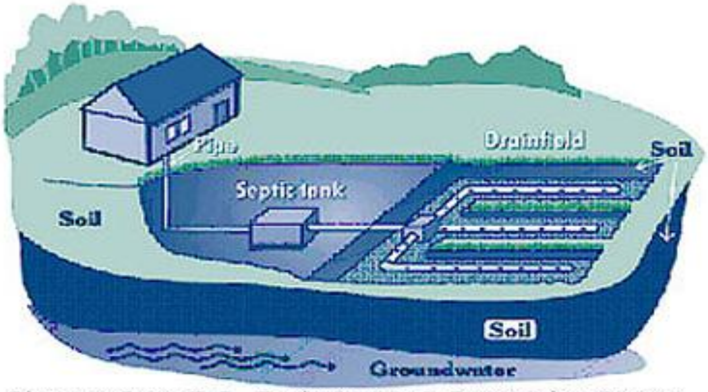

Diagram from U.S. Environmental Protection Agency

Pollutant Removal

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The pollutant removal efficiencies for a given septic system will depend upon the type of system chosen, site-specific conditions (terrain, geology, soils, seasonal high ground water levels, etc.), as well as factors about the use of the system (number of people using system, age of the system, maintenance history, etc.). Properly functioning septic systems can be effective at managing wastewater. EPA stated in a 1997 Report to Congress that "adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas." (http://cfpub.epa.gov/owm/septic/index.cfm).

Description:

Many Wyoming residents utilize an individual septic system (also referred to as an onsite system or decentralized wastewater system) to treat wastewater coming from their homes. While septic systems can be an effective and viable option for wastewater management, their effectiveness and viability is dependent on proper installation, operation, and maintenance. Failed septic systems can contribute pollutants, primarily pathogens and nitrogen, to surface water and ground water. The effectiveness of a selected type of septic system depends upon site conditions, such as terrain, lot layout, soil percolation rates, seasonal high ground water levels, and subsurface geology.

Septic system permits are required for the installation, repair, or replacement of individual or commercial sewage disposal systems with a wastewater flow of less than 2,000 gallons per day. Permits are required to assure that construction is consistent with regulations for the safeguarding of persons and property from hazards arising from unsanitary and unhealthy sewage disposal. Permits are required for all new construction where a septic tank and leachfield are needed, for changes or additions to existing buildings to ensure that the septic system capacity is adequate, and for any major repair or replacement of a septic system.

In some counties, the Wyoming Department of Environmental Quality (WDEQ) administers the small wastewater program, while in other counties the county government administers the program as the agent for WDEQ. If a county is not delegated, WDEQ issues septic system permits and permit applications must be submitted to the appropriate Water Quality Division District (see WDEQ Water and Wastewater Program website). Proposed systems must be in accordance with the Wyoming Water Quality Rules and Regulations (WQRR), Chapter 11, Part D: Septic Tank and/or Soil Absorption Systems.

Please contact the appropriate county or state agency for more information about septic system permits, the application process, inspection requirements, and for information about what to do if you are selling your property. Some counties require an inspection of the installed septic system prior to backfill. Owners of septic systems that generate a wastewater flow greater than 2,000 gallons per day should contact the WDEQ Underground Injection Control Program.

BMP 19: Septic Systems

Maintenance:

Proper maintenance of septic systems is critical to effective wastewater management and protection of underlying or nearby water resources. Many resources exist for homeowners to help guide them through the steps to take to ensure their system works properly. Three primary recommendations are to 1) get the system professionally inspected at least every 3 years, and pump the system as needed, 2) avoid driving or parking vehicles on the septic system drainfield, and plant only grass over and near the drainfield to avoid damage from roots, and 3) flush responsibly, as flushing household chemicals like paint, pesticides, oil, and antifreeze can destroy the biological treatment taking place in the septic system and flushing items, such as diapers, paper towels, and cat litter, can clog the septic system and damage components.

Signs of a failed septic system commonly include 1) liquid ponding over the leachfield or soggy spots, foul odors, and/or dark gray or black soils in the area of leachfield, 2) unusually lush, green vegetation in the area of the leachfield, 3) sewage backing up into the lowest drains in the house, and 4) gurgling of drains, slow drainage, and/or toilets not flushing well.

In some cases, CWA Section 319 funding may be available to help replace failed septic systems that are contributing pollutants to surface water quality impairments. Please contact the WDEQ Nonpoint Source Program or your local conservation district for potential Section 319 septic system cost-share opportunities. Qualifying septic systems must meet Wyoming Nonpoint Source Program Section 319 eligibility requirements, which are posted on the Nonpoint Source Program website.

References:

The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems. Updated 2010. EPA 832-B-05-001. U. S. Environmental Protection Agency.
http://cfpub.epa.gov/owm/septic/septic.cfm?page_id=289

Homeowner's Guide to Septic Systems. 2003. EPA 832-B-02-005. U.S. Environmental Protection Agency.
http://www.epa.gov/owm/septic/pubs/homeowner_guide_long.pdf

Onsite Wastewater Treatment Systems: The Maintenance and Care of Your Septic System. 2005. Rutgers Cooperative Research & Extension, Rutgers, The State University of New Jersey. Fact Sheet 840.
http://water.rutgers.edu/Fact_Sheets/fs840.pdf

The Septic Systems Information Website - How to Inspect, Test, Design, & Maintain or Repair Residential Septic Systems. InspectAPedia®.
http://inspectapedia.com/septic/septbook.htm

Top reasons for septic system failure and how to prevent them. Ready, M. 2008. Barnyards and Backyards, Summer 2008. University of Wyoming Cooperative Extension Service.
http://www.uwyo.edu/barnbackyard/_files/documents/magazine/2008/summer/septic-summer-2008.pdf

BMP 20: Low Impact Development

Photo of curvilinear street lined with "flat curbs" and bioretention cells. Source: SBCK

Pollutant Removal

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If properly carried out, low impact development (LID) can be very effective at stormwater pollution prevention and pollutant removal. Stormwater pollution is reduced by using preventative designs and measures. In addition, LID practices also promote pollutant removal through soil filtration and infiltration processes. All in all, by incorporating green infrastructure BMPs with preventative practices and sustainable designs, the LID strategy can greatly reduce stormwater pollution.

Description:

Low impact development (LID) is an alternative method of site development that strives to maintain or replicate the natural hydrologic regime of a site by using design and management techniques that integrate green space, native landscaping, and natural hydrologic functions to reduce runoff. LID principles and practices are based on controlling stormwater at the source by using small scale controls that are distributed throughout the site. Unlike traditional stormwater management systems that focus on mitigation and conveyance, low impact development practices focus on runoff prevention by encouraging on-site source control and infiltration.

Low impact development plans seek to maximize the area available for infiltration so that runoff volume and pollutant concentrations are reduced. LID strategies can be implemented at any point of development, but are most effective if they can be integrated during the initial site planning so that extensive site assessment of the natural hydrology, topography, soils, vegetation, and water features can be properly addressed.

One example of the use of LID as a design strategy can be seen when planning new housing developments. When incorporating LID into neighborhood designs, housing developments are often planned with higher density, clustered housing. This condensed design can preserve open spaces to promote infiltration and preserve natural habitats. Open, permeable land can also be preserved by narrowing street widths and lengths. In addition, low impact development plans can be designed to preserve and protect environmental sensitive sites, such as wetlands, woodlands, or other areas with densely established, native trees and vegetation. Although using LID as a design strategy is an effective practice, several other LID techniques can be utilized in new development and existing development.

LID strategies often utilize BMPs that can easily be incorporated into new and existing developed areas. These BMPs help promote infiltration, reduce runoff, promote ground water recharge, and thereby, can help maintain or replicate the natural hydrologic regime of a site. Several of the essential BMPs used as LID techniques have been previously discussed in this manual. For example, bioretention systems are a core LID practice. Grass swales, green roofs, permeable pavement systems, and rain barrels and cisterns are also often utilized as low impact development practices. These practices can promote the capture and reduction of stormwater runoff at the source and can promote infiltration and ground water recharge. In addition, these BMPs can be incorporated into new development site designs or can be used as stormwater retrofits for existing developed areas.

BMP 20: Low Impact Development

Description continued:

Low impact development can also encompass the implementation of preventative management practices, such as street sweeping, litter removal, and protection of natural and riparian vegetation. These practices can prevent pollutants from ever being introduced to the water system. Other preventative practices are discussed under BMP 18: Preventative Practices.

In general, low impact development has been found to be a simple, practical, and widely applicable approach to treating urban runoff. LID can effectively reduce runoff and pollutant loads. By capturing and infiltrating rainfall and snowmelt at the source, LID practices can reduce the amount of polluted stormwater runoff and can provide ground water recharge, thereby, improving overall water quality. LID practices can also provide some means of flood control by reducing the volume and velocity of runoff during peak flows. In addition, LID provides several stormwater retrofit options for highly urbanized areas, and LID practices are often less costly than other conventional stormwater controls, as practices are generally less expensive to construct and maintain.

Low impact development practices can also provide other benefits, such as enhancing the aesthetic values, increasing property values, providing or preserving wildlife habitat, providing recreational value, and reducing the urban heat island effect. The flexibility of LID approaches also provides a great benefit, as designs and practices can be tailored to specific site characteristics. However, the appropriateness of LID practices is dependent on certain site conditions, such as soil permeability, slope, and water table depth. Local rules and regulations may restrict certain practices, and current community desires for large, manicured lawns and wide streets may become an obstacle when trying to implement LID practices. However, if these obstacles can be overcome, low impact development can be a very effective and attractive integrated approach to controlling stormwater pollution in urban communities.

References:

The following are links to the documents used as references for this factsheet information. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

Low Impact Development (LID). Polluted Runoff (Nonpoint Source Pollution). 2011. U.S. Environmental Protection Agency.
http://www.epa.gov/owow/NPS/lid/

Low Impact Development: A Literature Review. 2000. EPA-841-B-00-005. U. S. Environmental Protection Agency, Office of Water, Washington, D.C.
http://www.epa.gov/owow/NPS/lid/lid.pdf

Low Impact Development (LID): A Sensible Approach to Land Development and Stormwater Management. Office of Environmental Health Hazard Assessment and California Water & Land Use Partnership.
http://www.coastal.ca.gov/nps/lid-factsheet.pdf

Low Impact Development: an economic fact sheet. NC Cooperative Extension: Watershed Education of Communities and Officials.
http://lid.okstate.edu/uploaded_files/LID_Economic%20Factsheet_WECO.pdf

Publications. 2011. Low Impact Development Center.
http://lowimpactdevelopment.org/publications.htm

Stormwater Strategies: Community Responses to Runoff Pollution. Chapter 12: Low Impact Development. 1999. Natural Resources Defense Council (NRDC).
http://www.nrdc.org/water/pollution/storm/chap12.asp

Appendix A: State and Federal Agency Resources for Regulatory Requirements

The following lists some common state and federal regulatory requirements, such as permits, that may need to be considered as part of BMP implementation. This list is not intended to be comprehensive and additional local permits or regulations may also apply. Please contact the appropriate government agency for more information. Your local city, town, or county government and/or conservation district may also be able to assist with understanding regulatory requirements associated with BMP implementation (see also Appendix B).

Permit/ Regulation	**Description**	**Agency**	**Contact and Website**
WYPDES Storm Water Permits	Some activities require WYPDES permits for storm water discharge, including runoff from large and small construction sites.	Wyoming Department of Environmental Quality, Water Quality Division, WYPDES Program	Barb Sahl 307-777-7570 http://deq.state.wy.us/wqd/WYPDES_Permitting/WYPDES_Storm_Water/stormwater.asp
Temporary Turbidity Waivers	Waiver to authorize temporary increases in turbidity for certain short-term, construction-related activities. Projects working in live waters and activities that may cause an excursion above allowable turbidity levels may qualify for a turbidity waiver.	Wyoming Department of Environmental Quality, Water Quality Division, Watershed Protection Program	Jeff Clark 307-777-6891 http://deq.state.wy.us/wqd/watershed/index.asp#Assure
Clean Water Act Section 404 permits	Any person, firm, or agency (including Federal, state, and local government agencies) planning to work in navigable waters of the United States, or discharge dredged or fill material in waters of the United States, including wetlands, must first obtain a permit from the Corps of Engineers.	United States Army Corps Engineers, Wyoming Regulatory Office	Matt Bilodeau 307-777-772-2300 http://www.nwo.usace.army.mil/html/od-rwy/Wyoming.htm
Section 401 Certifications	The WDEQ Water Quality Division reviews and issues water quality certifications under Section 401 of the Clean Water Act. Section 401 water quality certification is required for any federal license or permit which may result in a fill or discharge into waters of the United States (see Section 404 permits).	Wyoming Department of Environmental Quality, Water Quality Division, Watershed Protection Program	Jeremy ZumBerge 307-675-5638 http://deq.state.wy.us/wqd/watershed/index.asp#401_Certification_

Permit/ Regulation	Description	Agency	Contact and Website
Surface Water Rights Permits	Permits for any request for putting surface waters of the state to a beneficial use: includes transporting water through ditch or pipelines, storage in reservoirs, storage in smaller reservoir facilities for stockwater or wildlife purposes, and enlargements to existing ditch or storage facilities, and for instream flow purposes.	Wyoming State Engineer's Office	John Barnes 307-777-6475 http://seo.state.wy.us/SW/index.aspx
Ground Water Rights Permits	A permit is required from the State Engineer's Office prior to the drilling of all water wells; ground water rights are issued for the same beneficial uses as for surface water rights.	Wyoming State Engineer's Office	Lisa Lindemann 307-777-6163 http://seo.state.wy.us/GW/index.aspx
Pesticide Certification	Training, licensing, certification, and/or inspection of pesticide users, dealers, commercial applicators, and public agencies using restricted use pesticides.	Wyoming Department of Agriculture	Slade Franklin 307-777-6585 http://wyagric.state.wy.us/divisions/ts/sections-a-programs/148
Open Burn and Smoke Management	Vegetative and non-vegetative burns may require a permit and/or registration with the WDEQ Air Quality Division.	Wyoming Department of Environmental Quality, Air Quality Division	Brian Bohlmann 307-777-6993 http://deq.state.wy.us/aqd/Smoke%20Management%20and%20Open%20Burning.asp

Appendix B: Sources of Local BMP Technical Assistance and Contact Information

Wyoming Association of Conservation Districts
517 E. 19th Street
Cheyenne, WY 82001
Phone: (307) 632-5716
Fax: (307) 638-4099
Website: http://www.conservewy.com/

Wyoming Association of Municipalities
517 E. 19th Street
Cheyenne, WY 82001
Phone: (307) 632-5716
Website: http://www.wyomuni.org/

Wyoming County Commissioners Association
P.O. Box 86
409 W. 24th Street
Cheyenne, Wyoming 82003
Phone: (307) 632-5409
Fax: (307) 632-6533
Website: http://www.wyo-wcca.org/

Wyoming Conservation Districts

Campbell County Conservation District
PO Box 2577
601 4J Ct, Suite D
Gillette, WY 82717
307-682-1824 (phone) 307-682-3813 (fax)
www.cccdwy.net
icd@vcn.com

Cody Conservation District
1145 Sheridan Ave, Suite 5
Cody, WY 82414
307-899-0037
codycd@bresnan.net

Converse County Natural Resource District
911 Windriver Drive
Douglas, WY 82633
307-358-3050
michelle.huntington@wy.nacdnet.net
www.conserveconverse.org

Crook County Natural Resource District
PO Box 1070
117 S. 21st Street
Sundance, WY 82729
307-283-2501
sdm.mason@gmail.com
www.ccnrd.org

Dubois-Crowheart Conservation District
PO Box 27
706 Meckem Street
Dubois, WY 82513
307-455-2388
dccd@dteworld.com

Hot Springs Conservation District
601 Broadway, Suite A
Thermopolis, WY 82443
307-864-3488
carla.thomas@wy.nacdnet.net
www.conservewy.com/hscd.html

Lake DeSmet Conservation District
621 West Fetterman
Buffalo, WY 82834
307-684-2526
nikki.lohse@wy.nacdnet.net
www.ldcd.org

Laramie County Conservation District
11221 US Highway 30
Cheyenne, WY 82009
307-772-2600
info@lccdnet.org
www.lccdnet.org

Laramie Rivers Conservation District
5015 Stone Road
Laramie, WY 82070
307-721-0072
tony.hoch@wy.nacdnet.net
www.LRCD.net

Lincoln Conservation District
PO Box 98
110 Pine Street
Cokeville, WY 83114
307-279-3256
brenda.lazcanotegui@wy.nacdnet.net
www.lincolnconservationdistrict.org

Lingle-Fort Laramie Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Little Snake River Conservation District
PO Box 355
285 North Penland Street
Baggs, WY 82321
307-383-7860
lsrcd@yahoo.com

Lower Wind River Conservation District
508 N. Broadway
Riverton, WY 82501
307-856-7524
cathy.meyer@wy.nacdnet.net

Medicine Bow Conservation District
PO Box 6
510 Utah Street
Medicine Bow, WY 82324
307-379-2221
todd@medbowcd.org
www.medbowcd.org

Meeteetse Conservation District
PO Box 237
2103 State Street
Meeteetse, WY 82433
307-868-2484
mcd@tctwest.net
www.meeteetsecd-wy.gov

Natrona County Conservation District
5880 Enterprise Drive, Suite 100
Casper, WY 82609
307-234-4022
lisa.ogden@wy.nacdnet.net
www.natronacountyconservationdistrict.com

Niobrara Conservation District
PO Box 659
Lusk, WY 82225
307-334-2953
lshaw@wyoming.com

North Platte Valley Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Platte County Resource District
1502 Progress Court
Wheatland, WY 82201
307-322-9060
brady.irvine@wy.nacdnet.net
www.conservewy.com/pcrd.html

Popo Agie Conservation District
221 S. 2nd Street
Lander, WY 82520
307-332-3114
pacd@wyoming.com
www.popoagie.org

Powder River Conservation District
PO Box 48
Kaycee, WY 82639
307-738-2321
anita.bartlett@wy.nacdnet.net
www.powderrivercd.org

Powell-Clarks Fork Conservation District
1017 Highway 14A
Powell, WY 82435
307-754-9301
ann.trosper@wy.nacdnet.net
www.pcfcd.org

Saratoga-Encampment-Rawlins Conservation District
PO Box 633
101 Cypress Avenue
Saratoga, WY 82331
307-326-8156
jarrunner@gmail.com
www.sercd.org

Sheridan County Conservation District
1949 Sugarland Drive, Suite 102
Sheridan, WY 82801
307-672-5820
carrie.rogaczewski@wy.nacdnet.net
www.sccdofwyo.org/

Shoshone Conservation District
359 Nevada Avenue
Lovell, WY 82431
307-548-7422
shoshonecd@tctwest.net

South Big Horn Conservation District
408 Greybull Avenue
Greybull, WY 82426
307-765-2483
janet.hallsted@wy.nacdnet.net
www.conservewy.com/sbhcd

South Goshen Conservation District
1441 East M, Suite B
Torrington, WY 82240
307-532-4880
nancy.borton@wy.nacdnet.net
www.goshencountyconservationdistricts.com

Star Valley Conservation District
PO Box 216
61 E. 5th Avenue
Afton, WY 83110
307-885-7823
bashworth@starvalleycd.org
www.starvalleycd.org

Sublette County Conservation District
PO Box 647
1625 W. Pine Street
Pinedale, WY 82941
307-367-2257
sccd@wy.nacdnet.net
www.sublettecountycd.com

Sweetwater County Conservation District
79 Winston Drive, Suite 110
Rock Springs, WY 82901
307-362-3062
admin@swccd.us
www.swccd.us

Teton Conservation District
PO Box 1070
420 W. Pearl Avenue
Jackson, WY 83001
307-733-2110
randy@tetonconservation.org
www.tetonconservation.org

Uinta County Conservation District
PO Box 370
100 East Sage Street
Lyman, WY 82937
307-787-3794
ksabey@bvea.net
www.uintacountycd.com

Washakie County Conservation District
208 Shiloh Road
Worland, WY 82401
307-347-2456
wccd@rtconnect.net
www.washakiecd.com

Weston County Natural Resource District
1225 Washington Boulevard, #3
Newcastle, WY 82701
307-746-3264
jennifer.hinkhouse@wy.nacdnet.net

Appendix C: Wyoming Native Plant Species References

The following are links to more information on native plants of Wyoming. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

Recommended Species: Wyoming Recommended. 2011. Native Plant Information Network. Lady Bird Johnson Wildflower Center. The University of Texas at Austin.
http://www.wildflower.org/collections/collection.php?collection=WY

Rocky Mountain Herbarium. 2008. University of Wyoming.
http://www.rmh.uwyo.edu/index.php

Native Plant List: Montana and Wyoming. 2004. PlantNative.
http://www.plantnative.org/rpl-mtwy.htm

Wyoming Natural Diversity Database. 2012. University of Wyoming.
http://www.uwyo.edu/wyndd/index.html

Wyoming Native Plants. 2012. Bureau of Land Management, Wyoming.
http://www.blm.gov/wy/st/en/programs/pcp/communities.html

Appendix D: Prevention Tips for Homeowners

Table 2: Stormwater Pollution Prevention Practices for Homeowners	
Vehicle and Garage:	• Use a commercial car wash or wash your car on a lawn or other unpaved surfaces to minimize the amount of dirty, soapy water flowing into the storm drain. • Check cars, motorcycles, and other machinery and equipment for leaks and spills. Make repairs as soon as possible. Clean up spilled fluids with an absorbent material, such as kitty litter or sand, and properly dispose of the absorbent material. Do not rinse the spills into a nearby storm drain. • Recycle used oil and other automotive fluids at participating service stations or at local household hazardous waste collection centers. Don't dump these chemicals down the storm drain or dispose of them in your trash.
Lawn and Garden:	• Use pesticides and fertilizers sparingly. When use is necessary, use these chemicals in the recommended amounts. Avoid application if the forecast calls for rain to prevent chemicals from being washed to the local stream. • Select native plants and grasses that are drought and pest resistant. Native plants require less water, fertilizer, and pesticides. For more information on native landscaping see BMP 12. • Sweep up yard waste and compost or recycle yard waste when possible. • Avoid overwatering your lawn. Water in the evenings or morning, during the cool times of the day. • Cover piles of dirt and mulch being used in landscaping projects to prevent these particles from blowing or washing off into storm drains or local water bodies. Vegetate bare spots to prevent soil erosion. • Consider directing downspouts away from paved surfaces and onto lawns to increase infiltration and reduce polluted runoff or consider installing a rain barrel system to capture and reuse rainwater. For more information on rain barrels and cisterns see BMP 17.
Home Repair:	• Before beginning an outdoor project, locate the nearest storm drains and protect them from debris and other materials. • Sweep up and properly dispose of construction debris such as concrete and mortar. Do not sweep or wash debris into streets or gutters. • Use hazardous substances, like solvents and cleaners, in the smallest amounts possible. Be sure to follow the directions on the label and clean up spills immediately. Store substances properly to avoid leaks and spills and dispose of the waste properly. • When possible, purchase and use nontoxic, biodegradable, recycled, and recyclable products. • If painting your house, clean your paint brushes in a sink and not outdoors. Filter and reuse paint thinner when using oil-based paints. When finished, properly dispose of excess paints through a household hazardous waste collection program or donate unused paint to local organizations.
Septic System Use and Maintenance: **(see also BMP 19)**	• Septic systems should be professionally inspected at least every 3 years and pumped as needed. • Avoid driving or parking vehicles on the septic system drainfield and plant only grass over and near the drainfield to avoid damage from roots. • Flush responsibly. Flushing household chemicals like paint, pesticides, oil, and antifreeze can destroy the biological treatment taking place in the septic system. Other items, such as diapers, paper towels, and cat litter, can clog the septic system and damage components.
Pet Care:	• Pick up pet waste and dispose of it properly. Flushing pet waste is the best disposal method. Pet waste left on the ground can contaminate runoff with harmful bacteria and nutrients, which washes into the storm drain and eventually into local waterbodies. • Bathe pets in indoor tubs and properly dispose of pet shampoos and cleaners. When possible, purchase and use nontoxic shampoos, for the benefit of the pet and the environment.
Spas and Pools:	• Drain your spa or pool only when chlorine levels cannot be detected. • When possible, drain your spa or pool into the sanitary sewer system. • Properly store pool and spa chemicals to prevent leaks and spills, preferably in a covered area to avoid exposure to stormwater.

*For more references and pamphlets on household tips for stormwater pollution prevention, see the references section of BMP 16: Education.

Appendix E: Glossary

ADSORPTION - Adhesion of the molecules of a gas, liquid, or dissolved substance to a surface. Adsorption differs from absorption in that absorption is the assimilation or incorporation of a gas, liquid or dissolved substance into another substance.

AGGREGATE - Term for the stone or rock gravel used to fill in an infiltration BMP such as a trench or porous pavement. Clean-washed aggregate is simply aggregate that has been washed clean so that no sediment is associated with it.

BASEFLOW - The portion of stream flow that is not due to stormwater runoff and is supported by ground water seepage into a channel.

BERM - An earthen mound used to direct the flow of runoff around or through a BMP.

BEST MANAGEMENT PRACTICE (BMP) - Structural devices that temporarily store or treat urban stormwater runoff to reduce flooding, remove pollutants, and provide other amenities.

BIORETENTION SYSTEM: A shallow, landscaped depression that is designed to treat runoff and remove pollutants by replicating the biological processes that occur in the soil of a forest or meadow.

CHANNEL EROSION - The widening, deepening, and cutting of small channels and waterways, due to erosion caused by moderate to larger floods.

CHECK DAM - (a) A log or gabion structure placed perpendicular to a stream to enhance aquatic habitat. (b) An earthen or log structure, used in grass swales to reduce water velocities, promotes sediment deposition and enhances infiltration.

CISTERN: A simple on-lot treatment system composed of a partially or fully buried large tank that is designed to capture rooftop runoff from multiple down sprouts. Stored runoff, distributed out via an electrical pump, can be reused for landscaping and other non-potable uses without treatment. By collecting rooftop runoff, cisterns can reduce contributions of stormwater runoff from impervious cover.

CONCRETE GRID: A type of permeable pavement system that consists of manufactured concrete units with incorporated permeable openings, which vary in size depending on the design. Modular grid designs have regularly dispersed gaps that are filled with pervious materials such as sand, gravel, or grass. Monolithic grid designs, also known as permeable interlocking concrete pavement, are solid concrete units designed with small openings between their interlocking joints that are filled with highly permeable, small-sized aggregates.

CONTRIBUTING DRAINAGE AREA - Portion of the watershed contributing its runoff to the BMP in question.

DESIGN STORM - A rainfall event of specified size and return frequency (e.g. a storm that occurs only once every 2 years) that is used to calculate the runoff volume and peak discharge rate to a BMP.

DRY DETENTION POND – A stormwater basin designed to provide temporary storage of stormwater runoff. Dry ponds detain a portion of the runoff for some minimum time after a storm. They are designed to empty out between storm events and should not have any permanent standing water. Dry ponds are installed to control flooding and are capable of some pollutant removal through gravitational settling.

EXFILTRATION - The downward movement of runoff through the bottom of an infiltration BMP into the subsoil.

EXTENDED DETENTION - A stormwater design feature that provides for the gradual release of a volume of water over a 12 to 48 hour interval time to increase settling of urban pollutants and protect channels from frequent flooding.

FILTER FABRIC - Textile that is used to allow water to pass through while keeping sediment out (permeable) or used as a liner to prevent both runoff and sediment form passing through (impermeable).

FLOATING TREATMENT WETLAND - A constructed floating island that is vegetated with wetland plants and is designed to remove pollutants and nutrients primarily through plant uptake. Floating treatment wetlands do not require new land to construct, can be used in water bodies of any size, and have been found to be highly effective for nutrient removal.

FOREBAY - An extra storage area provided near an inlet of a BMP to trap incoming sediments before entering the BMP, thereby preventing excessive sedimentation and clogging in the BMP.

FRINGE WETLAND - Emergent aquatic vegetation intentionally planted along the perimeter of an open water BMP to enhance pollutant uptake, increase cover and forage for wildlife and aquatic species, and improve the appearance of a pond.

GABION - A large rectangular box of heavy gauge wire mesh which holds large cobbles and boulders. Can be used as a permeable wall or just used in streams and ponds to change flow patterns, stabilize banks, or prevent erosion.

GRASSED SWALE – A vegetated channel designed to treat and convey stormwater runoff. Pollutant and sediment removal is primarily accomplished by gravitational settling and physical and soil filtration. Grassed swales are often usefully utilized in as a pretreatment mechanism in a series of BMPs and can be modified with check dams to promote settling and infiltration. Their linear design also makes them useful for treating and conveying runoff from roadways.

GRAVITATIONAL SETTLING - The tendency of particulate matter to sink and settle when in water that is at a standstill or that is flowing at a moderate velocity.

GREEN ROOFS - Permanent rooftop planting systems, composed of various layers including but not limited to a water and root repellant layer, an optional insulation layer, a drainage system, a soil or substrate layer, and a plant layer. Green roofs are designed to reduce stormwater runoff from commercial, industrial, and residential buildings by mimicking natural processes where plants and soils absorb and store rainwater until it is later transpired into the air.

INFILTRATION BASIN – A shallow impoundment that is designed to capture and temporarily store incoming stormwater runoff until it gradually infiltrates into the soil through the sides and bottom of the basin. Infiltration basins remove pollutants and can provide ground water recharge via physical and soil filtration.

INFILTRATION TRENCH - A shallow rock-filled excavation that serves as a reservoir for stormwater runoff. Runoff is initially stored in the void spaces between the rocks, then gradually percolates and infiltrates through the bottom and sides of the trench into the surrounding soil matrix. Infiltration trenches remove pollutants and can provide ground water recharge via physical and soil filtration.

LEVEL SPREADER - A device used to spread out stormwater runoff uniformly over the ground surface as sheet flow. The purpose of level spreaders is to prevent concentrated, erosive flows from occurring and to enhance infiltration.

MATTING - The application of biodegradable, open-weave control fabrics or synthetic, nondegradable turf-reinforcement mats over bare or recently seeded soil. Matting can help prevent erosion and can promote vegetation establishment.

MICROBIAL DECOMPOSITION – The process of decomposition by microorganisms, which can degrade organic compounds to use as food resources and can absorb nutrients and metals into their tissues to support growth.

MICROPOOL - A smaller permanent pool used with a stormwater pond for particular circumstances, such as concern over the thermal impacts of larger ponds or impacts on existing wetlands.

MULCHING – The application of organic material over bare or recently seeded soil. Mulching can help prevent erosion, can slow runoff velocity, and can promote vegetation growth by retaining moisture.

MULTIPLE POND SYSTEM - A collective term for a cluster of pond designs that incorporate redundant runoff treatment techniques within a single pond or series of ponds. These pond designs employ a combination of two or more of the following: dry ponds, wet ponds, or stormwater wetlands.

NATIVE LANDSCAPING: A method of landscaping that manages stormwater by establishing carefully chosen, native, deep rooted plants that promote the capture and treatment of runoff.

NATURAL BUFFER - A low sloping area of maintained grassy or woody vegetation located between a pollutant source and a waterbody. A natural buffer is formed when a designated portion of a developed piece of land is left unaltered from its natural state during development. A natural vegetative buffer differs from a vegetated filter strip in that it is "natural" and in that they do not need to be used solely for water quality purposes. To be effective, such areas must be protected against concentrated flow.

PERMANENT POOL - A three to ten foot meter deep pool in a stormwater pond system that provides removal of urban pollutants through settling and biological uptake. Can also be referred to as a wet pond.

PERMANENT SLOPE DIVERSION - A channel or ridge that is generally constructed laterally along a slope and designed to intercept and divert runoff to a desired location.

PERMEABLE PAVEMENT SYSTEM - A durable, load-bearing pervious pavement surface with underlying stone beds that store rainwater before it infiltrates into the soil below. Permeable pavement can by replace impervious pavement systems and can reduce stormwater runoff and remove pollutants by allowing rainfall to directly infiltrate through the permeable paver and the stone bed to the underlying soil.

PERVIOUS CONCRETE - An alternative to conventional concrete that is made permeable by manufacturing the mixture with reduced sand or fine materials and incorporating void spaces. Runoff is infiltrated through the pervious concrete and into an underground stone reservoir, then gradually exfiltrates into the subsoil.

PHYSICAL FILTRATION - As particles pass across or through a surface, particulates can be separated from runoff by grass, leaves and other organic matter on the surface.

PLANT UPTAKE - Plant species rely on nutrients, such as phosphorus and nitrogen, as a food source; thus, they may intercept and remove nutrients and other pollutants from either surface or subsurface flow.

PLUNGE POOL - A small permanent pool located at either the inlet to a BMP or at the outfall form a BMP. The primary purpose of the pool is to dissipate the velocity of stormwater runoff, but it also can provide some pretreatment as well.

POROUS ASPHALT - An alternative to conventional asphalt that is made permeable by manufacturing the mixture with reduced sand or fine materials and incorporating void spaces. Runoff is infiltrated through the porous asphalt and into an underground stone reservoir, then gradually exfiltrates into the subsoil.

RAIN BARREL - A simple on-lot treatment system composed of a 55 gallon drum that is usually designed to capture rooftop runoff from a single down sprout of a home. Stored runoff, distributed out by gravity pressure through a hose attached to the bottom of the barrel, can be reused for landscaping and other non-potable uses without treatment. By collecting rooftop runoff, rain barrels can reduce contributions of stormwater runoff from impervious cover.

RETROFIT - The creation or modification of stormwater management systems in developed areas through the construction of BMP techniques that improve water quality. A retrofit can consist of the construction of a new BMP in the developed area, the enhancement of an older stormwater management structure, or a combination of improvement and new construction.

RIPARIAN AREAS- relatively narrow strips of densely vegetated land adjacent to streams, rivers, and creeks where vegetation is strongly influenced by the presence of water.

RIPRAP - A combination of large stone, cobbles, and boulders used to prevent erosion at inlets and outlets, line channels, stabilize soils and banks, reduce runoff velocities, or filter out sediment.

RUNOFF PRETREATMENT - Techniques to capture or trap coarse sediments before they enter a BMP to preserve storage volumes or prevent clogging within the BMP. Examples include forebays and micropools for pond BMPs and grass filter strips and filter fabric for infiltration BMPS.

SAND OR ORGANIC FILTER - Generally, a two-chambered filter system consisting of a settling chamber and a filter bed that are housed in fixed beds or concrete vaults. Runoff is designed to first flow into the pretreatment chamber, which removes large sediments through physical settling, and then runoff is treated for finer particles and other pollutants by being strained through the filter bed, which is often filled with sand but can be filled with peat, other organic mediums, or a combination of these materials.

SEDIMENT FOREBAY - Stormwater pretreatment design feature that employs the use of a small settling basin to settle out incoming sediments before they are delivered to a stormwater BMP. Sediment forebays are particularly useful in conjunction with infiltration devices, wet ponds, or stormwater wetlands.

SEEDING - A means of establishing permanent or temporary vegetation cover on disturbed areas by distributing plant seeds to prevent soil erosion and downstream sedimentation, slow and reduce runoff, and improve water quality.

SODDING - A means of establishing permanent or temporary grass cover on disturbed areas by transplanting established sections of turf or sod grass to prevent soil erosion and downstream sedimentation, slow and reduce runoff, and improve water quality.

SOIL FILTRATION - As water passes through soil, chemical, physical, and biological processes occur that can filter out sediment and soluble pollutants. Soluble and insoluble pollutants can be adsorbed by clay and organic matter in soil. Straining, microbial decomposition, and plant uptake can also assist with pollutant removal.

STORMWATER TREATMENT – Using detention, retention, filtration, or infiltration of a given volume of stormwater to remove urban pollutants and reduce frequent flooding.

STORMWATER WETLAND – A constructed, permanent shallow pool that creates conditions suitable for the growth of wetland plants. A constructed wetland system is designed to maximize the removal of pollutants from stormwater runoff through vegetation uptake, retention, and settling.

STREAM BUFFER - A strip of vegetated land adjacent to a stream that is preserved from development activity to protect water quality and aquatic and terrestrial habitats.

SUBSOIL - The bed or stratum of earth lying below the surface soil.

SWALE - A natural, concave depression or wide shallow ditch used to temporarily store, convey, and filter runoff.

TRASH AND DEBRIS REMOVAL - Mechanical or manual removal of debris, snags, and trash deposits that have accumulated in BMP systems or in stream banks. Removal should be performed regularly to prevent clogging, ensure proper functioning, and to improve the aesthetics of the BMP or stream.

UNDERDRAIN - Plastic pipes with holes drilled through the top, installed on the bottom of an infiltration BMP, or sand filter, which are used to collect and remove excess runoff.

VACUUM SWEEPING - A method of removing quantities of coarse-grained sediments from permeable pavement in order to prevent clogging. Not as effective in removing fine-grained pollutants.

VEGETATED FILTER STRIP – A uniformly graded, densely vegetated section of land that is designed to treat sheet flow runoff from adjacent land. Vegetated filter strips slow runoff velocities, promote infiltration into underlying soils, and remove sediment and pollutants through physical and soil filtration.

WET DETENTION POND – A detention pond that has a permanent pool of water throughout the year. Wet ponds capture and retain runoff during storm events and remove pollutants primarily through gravitational settling in the permanent pool or though biological activity and uptake in the pond.

WINDBREAK - A row of shrubs and trees, a hedge, or a fence that serves as protection against the wind. Vegetated windbreaks can also help stabilize soils, provide water quality benefits, and enhance aesthetics.

XERISCAPING – Landscaping or gardening in a way that reduces or eliminates the need for supplemental water from irrigation.

Appendix F: Additional References

The following are references for figures and photos that were not listed within the factsheet, along with full references for websites and documents that were provided within paragraphs, but not fully cited thereafter. References used for information on individual best management practices can be found at the end of each factsheet. If viewing this document in an electronic format, click on the blue underlined text to be redirected to the appropriate website. URL addresses are also provided for those who are viewing the hard copy. For websites outside the WDEQ, the WDEQ is not responsible for the content of or maintenance of those websites.

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